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PROGRESS REPORT ON OCCURRENCE AND REFINING OF SOME OF THE TENNESSEE VALLEY PRIMARY KAOLINS, THEIR USE IN VITREOUS CERAMIC WHITEWARE BODIES, AND RESULTS OF EXPERIMENTS RUN TO DEVELOP A MODIFIED TYPE OF VITREOUS TRANSLUCENT DINNERWARE MADE FROM ALL-AMERICAN MATERIALS*

By The Tennessee Valley Authority Ceramic Laboratory Staff

Abstract

This report is a collection of papers dealing with the occurrence and refining of primary North Carolina kaolins, their use in a vitreous china or porcelain-type dinnerware body, some notes on casting and plastic forming of these bodies, and some preliminary results in determining the best firing schedules.

The report also includes a statement of the purposes and aims of the laboratory and a description of the building and part of the equipment.

PART I, PURPOSE AND AIMS

The Ceramic Research Laboratory of the Tennessee Valley Authority was established in April, 1934, and laboratory work started in a building located at Norris, Tennessee, in March, 1935. The three-fold purpose of establishing such a laboratory was as follows:

(1) To aid in the development or standardization of the ceramic materials in the Valley and contiguous districts, especially those in a backward or dormant state, whose basic characteristics indicate that they could be at least partially substituted for imported materials, or where ceramic material resources are being wasted or unnecessarily exhausted.

(2) To assist in the development of high-temperature electrically heated kilns for the firing of ceramic ware by determining the primary basic characteristics of electric firing, the advantages or disadvantages of this type of firing, the comparative costs involved in erecting and operating electric kilns for high temperatures, and by basic development work on such factors as lives of heating elements, control of atmospheres, etc.

(3) To do basic research work on the production of vitreous dinnerware made from American materials with the hope that results would permit an American product to compete more effectively with the low-price foreign dinnerware now being imported in large quantities.

The basic characteristics of the primary white-firing kaolins of North Carolina have been studied by many investigators and found to be similar in many respects to those of English kaolins. It was hoped that a study of the kaolin reserves, an improved method of beneficiation of the crude kaolins, and a demonstration of methods best suited to working bodies made from these kaolins would aid in their more extended use in the entire American whiteware field. Furthermore, it was thought that intensive investigation of such materials as pegmatites, graphic granites, and semi-kaolinized feldspars could point the way to their wider use, thus lengthening the lives of the No. 1 feldspar deposits which are now being rapidly exhausted.

There appears to be little known about high-temperature electric firing, and consequently the use of the electric kiln is very limited at the temperatures where the majority of ceramic bodies mature. The possibilities of cleanliness and controllability when using electricity as the heating medium appear to be sufficient reasons for an investigation to determine whether or not electricity can compete with fuels when all factors are taken into consideration. It is believed that basic development work has suffered because of the costs involved in making a thorough investigation.

Even with the rapid technical development taking place in the dinnerware plants of the United States, the low-cost foreign-made vitreous ware still satisfies a large share of the American market. It is believed that an intensive investigation can point the way to the lower-cost manufacture of vitreous dinnerware.

As may be seen, each of the objectives can have many corollaries which may prove to be of more advantage and of greater interest than those mentioned.

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 22, 1937 (General Session). Received March 19, 1937.

PART II, DESCRIPTION OF THE LABORATORY

It was planned to hold the work at the laboratory as nearly as possible on a practical basis, inasmuch as the more scientific measurements are being made by ceramic divisions of other government bureaus. It is also a known fact that very small laboratory trials and results, while interesting and somewhat indicative, do not necessarily show a manufacturer what his troubles or costs will be when starting the manufacture of a new product. For this reason, the size of equipment was chosen to make possible the manufacture and processing of batches large enough at least to be termed semi-industrial and yet small enough to permit flexibility and experimentation over a large field. For the same reason, the laboratory personnel was limited to people experienced in factory production.

In addition to the equipment shown, the semi-industrial laboratory has a variable speed agitator of 800 pounds capacity for casting slip in which the temperature and speed of agitation are controlled. A well-equipped chemical laboratory as well as a small ceramic laboratory with mixers, ball mills, etc., is also maintained.

FIG. 1.—General view of the laboratory.

FIG. 2.—Filter press and vacuum pug mill. Capacity of the filter press is 1000 pounds, and it is equipped with a blank leaf so that smaller batches may be pumped as desired. Faces of the plates are ground true, and the plates are covered with two finely woven filter cloths so that a pressure of 200 pounds per square inch can be reached. In addition to the pump, a slip tank is provided which works on air pressure so that this method may be used if found desirable. Directly behind the filter press is a water filter for taking out any scale or other impurities present in the tap water.

FIG. 3.—Blunger, ball mill, and slip pump. Capacity of the blunger is 800 pounds, dry-weight basis, and of the ball mill, 500 pounds. Both of these machines are equipped with standard revolution counters. Two shaking lawns, not shown in the photograph, are provided so that the body slips pass through both lawns by gravity into a powerful magnetic separator and into an agitator located underneath the floor which has 1000 pounds capacity. The slip pump shown is of the standard diaphragm type so that the piston does not come in contact with the slip but works in water on the other side of the diaphragm. This pump works satisfactorily and will maintain an even pressure with a maximum fluctuation of 3 pounds.

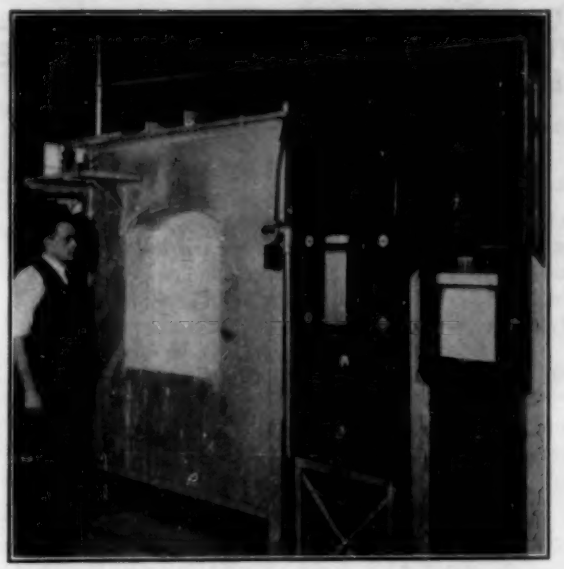

FIG. 4.—A Globar-heated furnace in which firing experiments described in Part VII were done and in which most of the preliminary trials have been made. This furnace is equipped with eight 33- by $1^1/_4$-inch Globars, 4 on the top and 4 in the bottom. Voltage on these bars is regulated by a three-phase transformer, each phase being regulated at 25 equal power steps from 80 volts to 210 volts. This makes it possible to connect the bars in series or parallel or a combination so that more heat can be put on the bottom, on the top, in the corners, or in the middle as desired. The furnace is also equipped for maintaining a reducing atmosphere by means of feeding carbon monoxide into the bottom of the kiln. The carbon monoxide is regulated and controlled by a meter and the automatic gas analyzer shown at the right of the kiln. Temperatures inside the kiln are measured by cones and controlled by thermocouples connected to the 8-point recorder shown at the extreme right. As many couples as may be desired may be put into the kiln at any point and connected to this recorder. By regulating the voltage on any set bars, it is possible to maintain equal heating conditions or extremely unequal conditions, as desired.

FIG. 5.—Interior view of the mold shop which is equipped to make limited amounts of molds by the standard methods.

FIG. 6.—The spreader, jigger, and casting bench; the spreader and jigger are of standard type, and the jigger is equipped with a variable-speed motor so that all speeds within reasonable limits can be reached and maintained.

PART III, STUDY OF PRIMARY NORTH CAROLINA KAOLINS AND LABORATORY EXPERIMENTS IN REFINING TO PRODUCE A MATERIAL SUITABLE FOR USE IN VITREOUS WHITEWARE

By R. E. Gould, A. J. Hedquist, and W. B. Boyd

Abstract

Fifty-one samples of crude North Carolina kaolin from different locations were tested by screen analysis, microscopic examination, and settling tests. Yields appeared to vary widely in the same deposit and from one deposit to another. There were indications that the ultimate products from different yield crudes would be similar in most respects and that if refined by using electrolytes the product would have good characteristics.

A recent geological survey indicates an available known tonnage sufficient to last for many years.

A description is given of laboratory refining which yielded a product that probably can be at least partially substituted for English kaolin.

I. Introduction*

The World War gave impetus to a large number of investigations for finding a suitable substitute for English china clay for use in the ceramic field. As a result, ceramic industries making a semivitreous ware have now changed almost exclusively to the use of American kaolins. It is a fact, however, that at present plants making a vitrified ware still use English china clay as the major part of the kaolin content, at least where color is of primary importance and some degree of translucency is desired. For other vitrified ware, where pure color is not quite so important, such as vitrified sanitary ware, English china clays are also used almost exclusively because of their desirable working properties, especially casting, as American kaolins have not worked so well into the manufacturing process.

Many writers[1–7] have reported favorable results in the use of mixtures of North Carolina, Georgia, and Florida kaolins and Kentucky and Tennessee ball clays; they have obtained vitrified bodies of good color and in some cases fair degrees of translucency. In spite of this, English china clays are still regarded as the most desirable by the vitrified whiteware manufacturers.

Leading whiteware manufacturers as well as clay producers were questioned as to why, in spite of the reported good results obtained with American kaolins, they were still using English china clay as the main kaolin.

An abstract of the answers received, which agrees with general existing opinions, is that (1) the Florida kaolins alone are difficult to substitute for the English china clay because of excessive shrinkage and a tendency to twist and crack when drying; (2) the Georgia clays, if used alone, have the same characteristics as the Florida clays, although not in as great an amount, and in addition they fire to a very poor color because of the iron and titanium oxide content; (3) a mixture of Georgia and Florida kaolins must also be rejected for the above reasons; (4) North Carolina kaolin alone or added to the mixture improves the color and cuts down the excessive shrinkage but decreases the plasticity and gives a rough texture to the bisque ware; and (5) the American kaolins in general are very poor casting clays.

Examination of typical chemical analyses of various American kaolins shows that the great

Table I

Chemical Analyses of Kaolins*

Name of material	Georgia kaolin† (%)	North Carolina kaolin† (%)	Delaware kaolin†	English china clay† (%)	Zettlitz kaolin‡ (%)
Ignition loss	13.71	13.03	11.84	12.37	12.95
SiO_2	45.30	48.46	48.53	47.00	46.90
Fe_2O_3	0.27	0.51	1.57	0.96	0.65
Al_2O_3	39.14	36.53	35.79	37.72	37.40
TiO_2	1.54	0.06	0.33	0.15	0.18
CaO	0.13	0.13	0.15	0.19	.29
MgO	.04	0.03	0.22	0.18	.27
K_2O	.15	1.34	1.80	1.57	.84
Na_2O	.10	0.21	0.19	0.23	.44
H_2O					

* R. A. Heindl, W. L. Pendergast, and L. E. Mong, "Kaolins; Effect of Firing Temperatures on Some of Their Physical Properties," *Bur. Standards Jour. Research*, **8** [2] 199–215 (1932); R. P. 410; a résumé of this paper was published in *Jour. Amer. Ceram. Soc.*, **16** [1] 75–76 (1933).

† Analysis made by J. F. Klekotka.

‡ Analysis made by J. I. Hoffman and taken from *Bur. Standards. Tech. News Bull.*, No. 138, p. 146 (1928).

* For footnote references throughout this paper, see Bibliography, pp. 213–14.

majority contains Fe_2O_3 or TiO_2 in quite appreciable amounts. Table I shows typical analyses of five representative kaolins in use in America and Europe. Table II gives chemical analyses of twenty-seven North Carolina kaolins. The analyses of North Carolina kaolins in the latter table show that the kaolins are particularly free from titanium oxide and are low in iron. Many checks have been made on representative samples of North Carolina kaolins which show the analyses given in Table II in respect to these impurities to be correct.

Rieke and Faust[8] have explained the influence of iron and titanium upon color and translucency of true porcelain bodies fired in oxidizing or reducing atmospheres. It appears from their work that color and translucency are largely functions of low iron and titanium contents (especially titanium) and of their ratio to each other and that color and translucency are related to one another at least to some extent. It is obvious that a clay, in order to replace at least partially the best English china clays, must first be as free from objectionable impurities as the English clays so that the fired color will be sufficiently good. This fact was used as the basic reason for an intensive study of the North Carolina primary kaolins.

II. History

References in the literature to North Carolina kaolins are frequent, although papers presenting a study of their properties and occurrences exclusively are few. In general, the impression is gained from a review of the writings that (1) the primary kaolins of North Carolina are limited in available tonnage; (2) the origin, crystal structure, grain size, and fired color are similar to the majority of English kaolins; (3) the plasticity and other working qualities of the refined kaolins are poor, and a plastic material probably could not be refined from the crudes because of the low content of fine grains; and (4) in using a mixture of American kaolins from North Carolina, Georgia, and Florida as a substitute for English clays, the more refractory nature of the American clays requires an adjustment in body composition or maturing temperature for successful use.

Watts[9] investigated the known deposits of

TABLE II

ANALYSES OF NORTH CAROLINA REFINED KAOLINS*

		SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O		K_2O	TiO_2	H_2O	Total
	Theoretical for kaolinite	46.3	39.8								13.9	100.00
(1)	Hog Rock Mine, Webster	46.95	37.73	0.15	Tr	Tr	0.18		0.60	0.05	13.99	99.65
(2)	" " " "	45.70	40.61	1.39	0.45	0.09		2.82			8.98	100.39
(3)	" " " "	46.47	38.82	0.89	.25	.28		0.75			13.34	100.80
(4)	Springer Pit, Webster	45.78	36.46	.28	.04	.50		0.25			13.40	99.84
(5)	Roda Mine, Sylva	46.41	38.46	.07	.07	.00	.17		.42		14.40	100.00
(6)	Buchanan Prospect, Sylva	46.30	39.06	.20	Tr	Tr	.11		.60	0.04	13.77	100.08
(7)	Forest Hill Mine, Sylva	49.20	37.58	.17	Tr	Tr	.13		.47	Tr	12.53	100.08
(8)	Old Sprucepine Mine, Spruce Pine	45.56	38.65	.41	.08	0.05	.55		.80	0.10	13.90	100.10
(9)	" " " "	45.20	38.45	.45	Tr	Tr	.00		.65	Tr	14.80	99.55
(10)	Tolley Mica Mine, Spruce Pine	46.35	38.30	.25	Tr	Tr	.00		.41	"	14.00	99.84
(11)	Harris Mine, Penland	45.61	38.63	.46	.08	0.08	.66		.90	"	13.57	99.99
(12)	Wilson Mine, Micaville	46.51	39.91	.11	.00	.00	.10		Tr		12.28	100.01
(13)	Hand Mine, Woodrow	46.41	37.76	.70	.09	.00	.17		0.55		13.46	
(14)	PiedmontTin Min.Co.,Lincolnton	48.50	37.35	.85	Tr	Tr	.32		1.02	"	12.00	100.04
(15)	Southern Clay Co., Franklin	46.67	39.07	.11	"	"	.11		0.25	0.02	13.22	99.45
(16)	Harris Clay Co., Bryson	46.95	37.24	.40	"	"	.24		0.49	0.05	14.10	99.47
(17)	Kinsland Mine, Waynesville	50.64	35.57	.25	"	"	.08		1.70	0.03	11.90	100.24
(18)	Gurney Clay Co., Franklin	44.00	40.79	.11	"	"	.07		0.55	Tr	14.72	100.24
(19)	McGuire Prospect, Franklin	46.35	39.00	.30	"	"	.00		.50	"	14.00	100.15
(20)	Raby Mica Mine, Franklin	46.90	38.60	.25	"	"	.26		.39	"	13.80	100.20
(21)	J. J. Smith Prospect, Franklin	48.05	37.69	.31	"	"	.02		.91	"	12.55	99.53
(22)	West Prospect, West Mills	48.92	36.37	.37	"	"	.11		.29	0.02	12.70	98.78
(23)	Brindle Pit, West Mills	45.41	39.56	.86		0.45	.09		.03		13.58	100.00
(24)	Elizabeth Smith Prospect, Burnsville	45.95	39.20	.05	"	Tr	Tr		.50	Tr	13.10	98.83
(25)	North Carolina Mining and Mfg. Co., Sylva	44.08	36.26	1.86	0.20	0.43			.50		13.56	99.96
(26)	Steele Prospect, Bostic's Mills	71.12	19.61	2.18		.17	.08		2.48		4.33	99.97
(27)	" " " "	49.33	35.90	3.15		.31	.14		3.15		8.00	99.98

* W. S. Bayley, "The Kaolins of North Carolina," *N. C. Geol. and Econ. Survey Bull.*, No. 29.

American primary kaolins, especially in North Carolina, and observed that these were in the form of small pockets or dykes. He made no estimate of the available tonnage but indicated that there is a probable enormous amount which could be refined in a centralized plant. He criticized the lack of control and the wasteful methods of refining. Bayley[10] later investigated the deposits of North Carolina. His work was more from the standpoint of an economic geologist, and he estimated the available reserves of refined kaolin to be in the neighborhood of 400,000 tons. He stated, however, that there is a great probability of much more which might be found at a later date. Wilson, Bennett, and Heath[11] stated that the amounts of primary kaolin in North Carolina, Pennsylvania, and Delaware are too small for large-scale exploitation. Schurecht[12] stated that, in regard to mechanical movement of water through kaolins, North Carolina and English clays are similar, but since the North Carolina primary kaolin is very limited in tonnage, the industry must look to the secondary Georgia kaolins for supplies.

Binns[13] found similarity between English and North Carolina kaolins in grain-size determinations. Klinefelter and Meyer[1] found that North Carolina and Delaware kaolins more closely resemble English clays than the American kaolins such as those of Georgia and Florida. They also noted that the fired color of North Carolina kaolin was as good as the best English china clay. Alexander[14] found that North Carolina crude kaolin yielded about 15% clay which was very coarse grained and very low in colloidal material, making a probable replacement for English china clay doubtful. Schurecht[15] said that grain size is important as related to physical properties and that the substitution of North Carolina kaolin for the finer-grained English clay will result in a porous product. Schurecht[16] also found, in measuring grain sizes of fine clay particles in suspension, that the resultant curves for North Carolina kaolins are quite similar to those of English china clays. France,[17] in ultramicroscopic examination of kaolins, found North Carolina kaolin to contain little colloidal material and consequently thought that the plasticity would be poor. Schurecht[12] found that the permeability and capillarity of North Carolina kaolins are similar to English china clays.

Watts,[2] in a study of ten kaolins in a standard body, found that North Carolina kaolin had a color equal to or better than the best English china clay. Riddle and McDanel,[3] in a study of vitreous china and porcelain bodies, successfully used a mixture of Georgia, Florida, North Carolina, and Delaware clays. Hemsteger and Stief[4] successfully substituted Georgia and North Carolina kaolins in a semiporcelain body. They found that the North Carolina kaolin reduced warpage but shortened the body. The increased refractoriness of the American kaolins could be overcome by extra fluxes or harder fire. In practical tests for compounding an all-American sanitaryware body, Foltz[5] found that North Carolina clay livered quickly and was not very successful. Bleininger and McDanel[6] found that a satisfactory approach to English china clay was a mixture of primary North Carolina or Maryland kaolin with a secondary such as Georgia or Florida kaolin. They found that the greater refractoriness of the American ball clays and kaolins could be easily compensated for by an increase in fire or a modification of the body. Klinefelter and Meyer[1] found that extra fluxes must be added to American kaolins to compensate for greater refractoriness when substituted for English clay. Fritz[7] claimed that American kaolins can be substituted in ceramic ware for English clays, provided proper adjustments are made in body composition.

Summing up, it appears that North Carolina kaolin, because of its origin and crystal structure similar to English china clay and because of its freedom from impurities of oxides of iron and titanium, should be basically right for at least partial substitution for English china clay, provided three important questions can be successfully answered. These are as follows:

(1) Do North Carolina kaolins exist in tonnages great enough to permit extensive use over a long period of time?

(2) Can a kaolin of constant quality, good physical properties, and at a price permissible in the whiteware industry be made from the crude material?

(3) Can this kaolin be successfully used as a replacement for English china clay in vitreous bodies, and will these bodies have the correct shrinkage, freedom from twisting and cracking, and good color if the North Carolina kaolin is used with some more plastic material such as Florida kaolin?

TABLE III. SCREEN ANALYSES AND MINERAL CLASSIFICATION

Screen No.		Sample 1 (%)	Sample 2 (%)	Sample 3 (%)	Sample 4 (%)	Sample 5 (%)	Sample 6 (%)	Sample 7 (%)	Sample 8 (%)	Sample 9 (%)	Sample 10 (%)	Sample 11 (%)	Sample 12 (%)	Sample 13 (%)	Sample 14 (%)	Sample 15 (%)	Sample 16 (%)
4-mesh mineral composition	Retained	1.4	3.9	0.7	0.2	1.3	4.1	5.2	9.2	21.5		2.4	0.6	3.02	1.94	2.38	2.7
	Quartz	50	50	50	50	35	90	80	95	50		75	50	80	80	90	80
	Feldspar	50	50	50	50	30		15	5	30		Trace	25	10	10	5	10
	Mica					35	10	5		20		25	25	10	10	5	10
12-mesh mineral composition	Retained	7.15	9.4	4.5	3.9	6.3	18	20.6	18.5	25.4	11.15	10.7	21.9	11.55	24.02	9.5	9.4
	Quartz	50	80	50	60	35	60	40	70	50	75	30	30	30	40	80	60
	Feldspar	45	15	50	45	30	Trace	25	20	50	10	Trace		10	Trace	Trace	Trace
	Mica	5	5			35	40	35	10		15	70	70	60	60	20	40
20-mesh mineral composition	Retained	12.8	8.5	7.1	12.5	11.6	11.4	12.76	8.3	13.1		19.71	17.35	15.75	16.5	8.35	5.1
	Quartz	50	50	50	35	35	60	40	50	50		40	50	20	30	50	40
	Feldspar	40	15	50	30	35	5	30	20	45		Trace	10	5	10	Trace	Trace
	Mica	10	35		35	30	35	30	30	5		60	40	75	60	50	60
40-mesh mineral composition	Retained	16.05	14.2	16.5	18.2	17.2	10	11.34	8.3	11.86	51.21	19.71	9.62	22.15	19.66	32.38	9.3
	Quartz	40	50	40	25	30	50	40	45	40	50	40	30	30	20	30	20
	Feldspar	40	15	20	25	30	5	30	35	45	20	Trace	20	Trace	20	10	Trace
	Mica	20	35	40	50	40	45	30	20	15	30	60	50	70	60	60	80
60-mesh mineral composition	Retained	11.0	11.2	14.8	8.8	9.3	5.2	5.2	6.84	5.58		12.97	9.62	10.95	7.86	9.09	6.0
	Quartz	40	40	40	30	20	30	35	40	40		30	10	40	30	30	50
	Feldspar	20	20	20	25	30	30	35	30	45		10	20	Trace	Trace	10	Trace
	Mica	40	40	40	45	50	40	30	30	15		60	70	60	70	60	50
80-mesh mineral composition	Retained	4.0	8	7.6	6.8	5.8	2.9	4.12	4.25	3.24	9.92	4.45	4.36	3.58	2.82	9.05	5.2
	Quartz	15	30	35	25	30	40	30	25	30	10	40	30	30	20	30	25
	Feldspar	15	20	10	25	20	30	15	25	10	20	5	5	20	15	25	10
	Mica	70	50	55	50	50	30	55	50	60	70	55	65	50	65	45	65
100-mesh mineral composition	Retained	4.35	5.2	7.3	5.7	5.7	3.0	2.17	2.02	1.62		4.83	2.10	2.83	3.82	2.90	3.8
	Quartz	20	30	30	35	30	25	40	25	30		20	20	40	35	35	45
	Feldspar	30	20	25	15	20	25	10	25	10		5	5	25	25	25	10
	Mica	50	30	45	50	50	30	30	25	30		70	60	40	30	40	40
	Clay min.		20				20	20	25	30		5	15		10		5
120-mesh mineral composition	Retained	2.5	3.7	4.4	4.3	3.5	3.6	2.14	2.96	2.29	4.35	3.85	1.74	2.60	1.95	1.75	7.7
	Quartz	25	25	10	25	20	25	30	25	30	15	20	10	40	30	30	50
	Feldspar	20	15	20	20	15	30	10	10	20	20	5	10	20	20	30	10
	Mica	40	40	70	55	65	30	40	30	30	70	70	60	40	40	40	30
	Clay min.	15	20				15	20	35	20		5	20		10		10
140-mesh mineral composition	Retained	2.17	2.4	2.6	2.4	2.0	0.6	0.91	0.64	1.38		1.95	1.30	0.91	0.95	1.40	
	Quartz	40	30	20	15	20	15	30	25	30		30	20	40	20	30	
	Feldspar	5	5	20	15	20	15	10	10	20		5	10	30	20	30	
	Mica	40	35	60	70	60	50	40	30	30		60	40	20	30	40	
	Clay min.	15	30				20	20	35	20		5	30	10	30		
150-mesh mineral composition	Retained	0.61	0.4	1.5	0.7	1.0	0.4	1.31	0.3	0.28		0.45	0.26	0.62	0.57	0.12	3.0
	Quartz	20	25	10	15	10	30	30	25	30		40	30	30	20	20	40
	Feldspar	10	5	30	20	15	20	10	10	20		5	5	20	30	20	15
	Mica	50	40	60	65	75	50	40	30	40		50	50	40	40	50	30
	Clay min.	20	30					20	35	10		5	15	10	10	10	15
180-mesh mineral composition	Retained	2.85	4.0	2.8	3.5	2.7	2.7	1.68	2.35	0.88	2.39	2.52	1.35	2.21	1.44	1.75	3.1
	Quartz	20	20	10	15	15	30	25	25	25	10	30	20	30	30	40	30
	Feldspar	10	10	20	10	35	20	25	30	40	10	5	5	20	25	20	20
	Mica	50	30	70	75	50	50	25	30	35	65	60	50	50	40	40	40
	Clay min.	20	40					25	15		15	5	25		5		10

TABLE III. SCREEN ANALYSES AND MINERAL CLASSIFICATION (*continued*)

200-mesh mineral composition	Retained	2.05	1.3	2.2	1.8	1.8	1.2	1.95	1.79	0.83		1.20	0.48	0.76	0.88	0.29	0.8
	Quartz	20	20	10	20	15	25	25	25	25		20	20	40	25	40	30
	Feldspar	10	10	20	15	20	20	10	10	10		5	10	25	25	20	20
	Mica	50	30	70	65	65	50	30	25	25		60	60	30	50	30	40
	Clay min.	20	40				5	35	40	40		15	10	5		10	10
230-mesh mineral composition	Retained	2.44	2.7	2.0	2.2	1.1	2.8	1.42	1.12	0.77	0.84	1.71	1.65	1.00	1.42	0.48	3.2
	Quartz	20	10	10	15	10	20	20	25	25	20	30	20	25	30	30	20
	Feldspar	10	10	15	10	25	20	10	10	10	10	5	10	20	20	20	20
	Mica	50	40	75	75	65	50	35	25	30	65	55	60	25	50	45	40
	Clay min.	20	40				10	35	40	35	5	10	10	30		5	20
250-mesh mineral composition	Retained	1.46	1.1	1.1	1.2	1.1	1.4	0.92	1.23	0.60		1.22	0.66	0.54	0.61	0.27	2.0
	Quartz	30	10	10	25	15	20	20	15	30		30	20	30	20	30	20
	Feldspar	10	10	30	25	25	20	10	5	10		10	5	20	20	20	25
	Mica	40	40	60	50	60	50	35	30	30		60	50	30	60	50	35
	Clay min.	20	40				10	35	50	30			25	20			20
300-mesh mineral composition	Retained	3.7	2.7	2.9	3.4	4.2	2.5	2.24	2.82	1.31		3.00	1.85	1.08	2.35	1.67	5.0
	Quartz	20	10	10	25	25	20	20	15	20		30	20	15	10	30	30
	Feldspar	10	10	35	35	35	20	10	5	20		10	10	20	20	15	20
	Mica	50	40	55	40	40	50	35	35	35		60	45	40	40	35	40
	Clay min.	20	40				10	35	45	25			25	25	30	20	10
325-mesh mineral composition	Retained	1.05	1.0	1.1	1.3	0.7	1.2	1.10	0.99	0.65	2.25	0.82	0.42	0.41	1.02	0.19	0.6
	Quartz	10	10	10	15	20	20	20	15	20	10	5	20	20	20	30	30
	Feldspar	10	10	25	25	25	20	10	5	10	10	5	5	15	10	10	20
	Mica	60	40	65	60	55	50	35	35	35	60	50	45	50	50	40	40
	Clay min.	20	40				10	35	45	35	20	40	30	15	20	20	10
325-mesh mineral composition	Passed	23.5	20.3	21.0	23.1	23.7	29.2	24.92	25.43	8.66	17.79	17.59	16.47	20.04	12.19	18.39	33.1
	Quartz	5	5	5	10	5	10	15	10	10	10	5	5	10	5	10	20
	Feldspar	5	5	5	30	10	5	5	Trace	5	Trace	5	Trace	10	5	5	20
	Mica	40	30	25	30	25	20	30	60	20	10	20	5	25	10	20	30
	Clay min.	50	60	70	30	60	65	50	30	65	80	70	90	55	80	65	30
Remarks																	
Plasticity		Short	Fairly plastic	Fairly plastic	Short	Fairly plastic	Fairly plastic	Fairly plastic	Short	Short	Fairly plastic	Very plastic	Fairly plastic	Fairly plastic	Fairly plastic	Fairly plastic	Short
Absorption (cone 14)		15.4	16.2	18.4	14.8	15.7	14.9	12.85	10.6	18.7	13.6	14.5	12.85	13.9	16.3	13.7	13.2
Fired color (cone 14)		Good white	Good white	Good white	Fair white	Good white	Good white	Good white	Good white	Fair white	Good white	Good white	Good white	Good white	Fair white	Good white	Good white

Mineralogical percentages are microscopic approximations from examinations by Irma Rhode.

Screen No.		Sample 17 (%)	Sample 18 (%)	Sample 19 (%)	Sample 20 (%)	Sample 21 (%)	Sample 22 (%)	Sample 23 (%)	Sample 24 (%)	Sample 25 (%)	Sample 26 (%)	Sample 27 (%)	Sample 28 (%)	Sample 29 (%)	Sample 30 (%)	Sample 31 (%)	Sample 32 (%)
12-mesh mineral composition	Retained	11.6	11.8	17.6	7.7	34.0	10.5	30.4	15.4	24.3	4.7	21.4	14.8	18.0	28.4	14.7	5.0
	Quartz	70.0	60.0	80.0	70.0	30.0	80.0	70.0	80.0	80.0	70.0	80.0	90.0	80.0	60.0	75.0	40.0
	Feldspar	Trace						5.0					5.0	5.0			Trace
	Mica	30.0	40.0	20.0	30.0	50.0	15.0	20.0	15.0	20.0		5.0	5.0	10.0	30.0	20.0	60.0
	Clay min.	Trace		Trace	Trace	20.0	5.0	5.0	5.0		30.0	15.0		5.0	10.0	5.0	Trace
20-mesh mineral composition	Retained	16.2	12.0	14.9	14.6	11.2	21.5	14.3	25.9	12.2	11.5	7.5	10.8	17.2	13.6	18.0	13.4
	Quartz	60.0	70.0	60.0	60.0	40.0	60.0	50.0	40.0	50.0	80.0	50.0	60.0	70.0	10.0	50.0	50.0
	Feldspar	Trace	Trace	Trace				5.0			5.0	5.0	5.0	10.0		Trace	Trace
	Mica	30.0	30.0	40.0	30.0	40.0	30.0	40.0	50.0	40.0	5.0	20.0	30.0	20.0	70.0	40.0	40.0
	Clay min.	10.0	Trace	Trace	10.0	20.0	10.0	5.0	10.0	10.0	10.0	25.0	5.0		20.0	10.0	10.0

40-mesh mineral composition	Retained	18.7	20.0	20.1	14.9	11.6	22.8	12.2	13.1	8.7	20.2	7.3	13.7	20.1	15.1	22.4	20.8
	Quartz	60.0	30.0	30.0	45.0	30.0	30.0	30.0	30.0	45.0	30.0	40.0	50.0	40.0	10.0	50.0	40.0
	Feldspar	Trace	Trace	Trace		5.0		Trace			10.0	10.0	10.0	5.0		Trace	Trace
	Mica	30.0	70.0	70.0	50.0	30.0	60.0	40.0	55.0	40.0	50.0	30.0	30.0	40.0	70.0	40.0	40.0
	Clay min.	10.0	Trace	Trace	5.0	35.0	10.0	30.0	15.0	15.0	10.0	20.0	10.0	15.0	20.0	10.0	20.0
60-mesh mineral composition	Retained	12.4	6.6	7.2	9.9	9.7	7.1	6.1	4.8	5.3	6.5	5.0	11.0	10.0	6.8	7.4	8.3
	Quartz	50.0	50.0	45.0	45.0	30.0	15.0	30.0	30.0	40.0	30.0	30.0	30.0	30.0	15.0	20.0	30.0
	Feldspar	Trace			5.0	5.0		5.0	5.0	Trace	10.0	20.0	10.0	5.0	5.0	10.0	5.0
	Mica	40.0	50.0	45.0	35.0	30.0	70.0	30.0	55.0	40.0	50.0	25.0	30.0	50.0	50.0	60.0	50.0
	Clay min.	10.0	Trace	10.0	15.0	35.0	15.0	35.0	10.0	20.0	10.0	25.0	30.0	15.0	30.0	10.0	15.0
80-mesh mineral composition	Retained	9.0	3.0	3.9	9.6	3.0	2.8	2.7	3.9	2.4	8.6	2.9	3.2	3.2	4.6	3.1	4.1
	Quartz	40.0	20.0	30.0	50.0	20.0	10.0	30.0	20.0	30.0	30.0	25.0	25.0	15.0	20.0	20.0	35.0
	Feldspar	Trace			5.0	5.0		5.0	5.0	Trace	20.0	15.0	15.0	10.0	5.0	10.0	Trace
	Mica	40.0	80.0	50.0	35.0	40.0	75.0	40.0	50.0	45.0	40.0	10.0	40.0	60.0	20.0	60.0	45.0
	Clay min.	20.0	Trace	20.0	10.0	35.0	15.0	25.0	25.0	25.0	10.0	50.0	20.0	15.0	55.0	10.0	20.0
100-mesh mineral composition	Retained	3.8	5.2	1.3	2.6		2.5	1.4	3.0	1.4	7.5	7.5	4.4	2.1	2.5	2.8	5.2
	Quartz	40.0	20.0	10.0	20.0		15.0	5.0	20.0	5.0	Trace	10.0	10.0	5.0	5.0	Trace	10.0
	Feldspar	Trace	Trace	Trace	5.0		5.0	5.0	5.0	5.0	10.0	20.0	5.0	5.0	5.0	5.0	
	Mica	50.0	30.0	30.0	35.0		40.0	10.0	20.0	20.0	30.0	20.0	30.0	50.0	15.0	45.0	50.0
	Clay min.	10.0	50.0	60.0	40.0		40.0	80.0	55.0	70.0	60.0	50.0	55.0	40.0	75.0	50.0	40.0
150-mesh mineral composition	Retained	4.2	5.4	2.5	6.0	4.7	2.0	1.3	3.1	2.1	4.8	5.1	4.2	3.4	1.3	2.2	6.0
	Quartz	10.0	20.0	10.0	20.0	10.0	15.0	5.0	20.0	5.0	Trace	10.0	10.0	5.0	5.0	Trace	10.0
	Feldspar	Trace	Trace	Trace	5.0	5.0	5.0	5.0	5.0	5.0	10.0	20.0	5.0	5.0	5.0	5.0	
	Mica	50.0	30.0	30.0	35.0	20.0	40.0	10.0	20.0	20.0	30.0	20.0	30.0	50.0	15.0	45.0	50.0
	Clay min.	40.0	50.0	60.0	40.0	65.0	40.0	80.0	55.0	70.0	60.0	50.0	55.0	40.0	75.0	50.0	40.0
270-mesh mineral composition	Retained	5.6	10.6	5.7	8.9	5.2	5.2	4.4	5.0	5.3	4.9	13.2	8.5	6.6	4.9	5.0	11.4
	Quartz	10.0	20.0	10.0	20.0	10.0	15.0	5.0	20.0	5.0	Trace	10.0	10.0	5.0	5.0	Trace	10.0
	Feldspar	Trace	Trace	Trace	5.0	5.0	5.0	5.0	5.0	5.0	10.0	20.0	5.0	5.0	5.0	5.0	
	Mica	50.0	30.0	30.0	35.0	20.0	40.0	10.0	20.0	20.0	30.0	20.0	30.0	50.0	15.0	45.0	50.0
	Clay min.	40.0	50.0	60.0	40.0	65.0	40.0	80.0	55.0	70.0	60.0	50.0	55.0	40.0	75.0	50.0	40.0
325-mesh mineral composition	Retained	2.6	4.9	3.6	4.6	2.1	1.7	2.0	2.3	1.9	2.4	3.8	8.4	2.1	1.5	1.6	5.8
	Quartz	10.0	20.0	10.0	20.0	10.0	15.0	5.0	20.0	5.0	Trace	10.0	10.0	5.0	5.0	Trace	10.0
	Feldspar	Trace	Trace	Trace	5.0	5.0	5.0	5.0	5.0	5.0	10.0	20.0	5.0	5.0	5.0	5.0	
	Mica	50.0	30.0	30.0	35.0	20.0	40.0	10.0	20.0	20.0	30.0	20.0	30.0	50.0	15.0	45.0	50.0
	Clay min.	40.0	50.0	60.0	40.0	65.0	40.0	80.0	55.0	70.0	60.0	50.0	55.0	40.0	75.0	50.0	40.0
400-mesh mineral composition	Retained	2.5	1.5	2.6	2.7	2.3	1.6	2.2	2.2	1.7	2.6	0.9	7.9	3.0	2.8	1.9	2.6
	Quartz	10.0	20.0	10.0	20.0	10.0	15.0	5.0	20.0	5.0	Trace	10.0	10.0	5.0	5.0	Trace	10.0
	Feldspar	Trace	Trace	Trace	5.0	5.0	5.0	5.0	5.0	5.0	10.0	20.0	5.0	5.0	5.0	5.0	
	Mica	50.0	30.0	30.0	35.0	20.0	40.0	10.0	20.0	20.0	30.0	20.0	30.0	50.0	15.0	45.0	50.0
	Clay min.	40.0	50.0	60.0	40.0	65.0	40.0	80.0	55.0	70.0	60.0	50.0	55.0	40.0	75.0	50.0	40.0
400-mesh mineral composition	Passed	13.5	31.2	20.7	18.5	16.3	22.3	23.3	21.2	34.6	25.2	25.5	13.2	14.3	18.6	21.0	17.5
	Quartz	15.0	5.0	5.0	10.0	10.0	10.0	5.0	10.0	5.0	10.0	5.0	5.0	5.0	5.0	10.0	5.0
	Feldspar	5.0	5.0	Trace	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0	5.0	5.0	5.0	5.0	5.0
	Mica	30.0	50.0	30.0	25.0	20.0	20.0	10.0	25.0	10.0	20.0	10.0	30.0	25.0	20.0	30.0	40.0
	Clay min.	50.0	40.0	60.0	60.0	65.0	65.0	80.0	60.0	80.0	65.0	75.0	60.0	65.0	70.0	55.0	50.0
Remarks																	
Plasticity		Fair	Good	Fair	Short	Short	Very good	Very good	Good	Good	Very good	Fair	Fair	Fair	Fair	Fair	Fair
Absorption Cone 14		16.2	15.2	16.2	15.9	14.7	18.2	15.4	14.2	15.5	17.3	16.9	15.4	20.4	23.2	16.9	15.4
Fired color Cone 14		Good white	Good white	Good white	Good white	Good white	Good white	Good white	Good white	Good white	Good white	Good white	Good white	Good white	Good white	Good white	Gray

Mineral percentages are approximate from microscopic examinations by Irma Rhode.

TABLE III. SCREEN ANALYSES AND MINERAL CLASSIFICATION (*continued*)

Screen No.		Sample 33 (%)	Sample 34 (%)	Sample 35 (%)	Sample 36 (%)	Sample 37 (%)	Sample 38 (%)	Sample 39 (%)	Sample 40 (%)	Sample 41 (%)	Sample 42 (%)	Sample 43 (%)	Sample 44 (%)	Sample 45 (%)	Sample 46 (%)
10-mesh	Retained	6.1	4.8	24.3	22.5	13.1	9.2*	22.7	22.7	21.8	11.6	9.7	6.15	18.5	19.1
mineral	Quartz									40.0	70.0	80.0	60.0	95.0	80.0
composition	Feldspar									Trace					
	Mica									50.0	20.0	20.0	40.0	5.0	20.0
	Clay min.									10.0	10.0				Trace
20-mesh	Retained	5.3	5.2	7.4	8.5	16.0	16.3	13.8	16.2	24.6	19.7	13.8	16.75	13.1	12.9
mineral	Quartz									40.0	30.0	60.0	65.0	40.0	75.0
composition	Feldspar														
	Mica									40.0	50.0	40.0	30.0	60.0	10.0
	Clay min.									20.0	20.0		5.0		15.0
35-mesh	Retained	12.6	10.2	3.5	6.2	14.2	16.3	9.9	10.5	13.4	20.4	15.9	16.69	11.5	12.1
mineral	Quartz									40.0	50.0	30.0	30.0	50.0	15.0
composition	Feldspar														5.0
	Mica									30.0	30.0	50.0	60.0	50.0	65.0
	Clay min.									30.0	20.0	20.0	10.0		15.0
65-mesh	Retained	21.0	32.3	5.5	10.4	14.0	22.4	9.4	13.6	10.5	16.1	16.3	12.72	11.5	12.7
mineral	Quartz									35.0	50.0	60.0	30.0	45.0	10.0
composition	Feldspar														5.0
	Mica									25.0	30.0	25.0	50.0	50.0	60.0
	Clay min.									40.0	20.0	15.0	20.0	5.0	25.0
150-mesh	Retained	15.2	13.1	9.0	14.8	10.0	7.7	8.6	8.2	8.2	7.5	14.4	10.95	14.9	9.5
mineral	Quartz									20.0	25.0	20.0	25.0	20.0	10.0
composition	Feldspar														5.0
	Mica									45.0	45.0	50.0	55.0	50.0	60.0
	Clay min.									35.0	30.0	30.0	20.0	30.0	25.0
270-mesh	Retained	8.4	10.9	7.1	10.4	4.1	5.7	7.0	8.9	7.3	6.1	6.9	8.72	8.7	7.6
mineral	Quartz									20.0	20.0	15.0	15.0	10.0	10.0
composition	Feldspar														5.0
	Mica									35.0	30.0	30.0	50.0	40.0	55.0
	Clay min.									45.0	50.0	55.0	35.0	50.0	25.0
325-mesh	Retained	0.7	0.5	1.2	1.7	2.2	1.8	4.0	2.7	1.7	2.4	2.1	1.40	3.6	2.1
mineral	Quartz									15.0	15.0	15.0	15.0	10.0	10.0
composition	Feldspar														Trace
	Mica									35.0	35.0	30.0	50.0	40.0	50.0
	Clay min.									50.0	50.0	50.0	35.0	50.0	40.0
400-mesh	Retained	3.2	3.1	4.4	1.8	1.2	2.0	3.0	1.6	1.9	2.4	2.5	1.02	0.4	1.8
mineral	Quartz									15.0	15.0	10.0	5.0	10.0	Trace
composition	Feldspar														Trace
	Mica									35.0	25.0	25.0	40.0	40.0	40.0
	Clay min.									50.0	60.0	65.0	55.0	50.0	60.0
400-mesh	Passed	27.5	19.9	37.6	23.7	25.2	18.6	21.6	15.6	10.4	13.9	18.4	25.60	17.7	22.2
mineral	Quartz									10.0	Trace	5.0	5.0	10.0	5.0
composition	Feldspar														
	Mica									40.0	40.0	15.0	5.0	15.0	30.0
	Clay min.									50.0	60.0	80.0	90.0	75.0	65.0
Remarks															
Plasticity		Fair	Good	Good	Fair	Good	Good	Very good	Good	Fair	Short	Fair	Fair	Fair	Good
Absorption (cone 14)		14.7	18.1	14.9	12.8	14.5	15.5	16.0	14.4	14.3	14.1	10.6	12.0	14.5	14.5
Fired color (cone 14)		Fair white	Fair white	Fair white	Fair white	Good white	Fair white	Good white	Good white	Good white	Good white	Fair white	Fair white	Fair white	Fair white

Mineral percentages are approximate from microscopic examination by Irma Rhode.

III. Procedure

(1) Known Existing Tonnage of North Carolina Kaolin

Bryson[176] estimates the available tonnage of refined kaolin to be 25,000,000 tons. This figure has been checked by the laboratory staff and by Frank L. Hess,* who said, "Using a clay content of 15% . . . . . the kaolin resources of North Carolina apparently amount to more than 25,000,000 tons." On a recent short inspection

* Principal Mineralogist of the United States Bureau of Mines. (Letter to TVA Ceramic Laboratory, March 6, 1937.)

TABLE III. SCREEN ANALYSES AND MINERAL CLASSIFICATION (*concluded*)

Screen No.		Sample 47 (%)	Sample 48 (%)	Sample 49 (%)	Sample 50 (%)	Sample 51 (%)
12-mesh	Retained	29.4	18.2	15.4	11.8	15.8
mineral	Quartz	50.0	50.0	50.0	70.0	90.0
composition	Feldspar			Trace	30.0	
	Mica	40.0	40.0	30.0		10.0
	Clay min.	10.0	10.0	20.0		
20-mesh	Retained	10.9	28.2	18.4	4.6	16.8
mineral	Quartz	40.0	45.0	80.0	45.0	30.0
composition	Feldspar			Trace	45.0	
	Mica	40.0	35.0	10.0	10.0	60.0
	Clay min.	20.0	20.0	10.0		10.0
40-mesh	Retained	12.3	16.9	20.7	8.1	21.0
mineral	Quartz	30.0	45.0	30.0	30.0	20.0
composition	Feldspar			5.0	60.0	
	Mica	40.0	45.0	45.0	10.0	60.0
	Clay min.	30.0	10.0	20.0		20.0
60-mesh	Retained	4.7	9.9	7.2	8.1	4.1
mineral	Quartz	25.0	35.0	15.0	5.0	10.0
composition	Feldspar		5.0	5.0	80.0	
	Mica	50.0	35.0	60.0	5.0	80.0
	Clay min.	25.0	25.0	20.0	10.0	10.0
80-mesh	Retained	3.1	4.2	3.8	7.4	4.6
mineral	Quartz	10.0	25.0	20.0	5.0	Trace
composition	Feldspar		5.0		80.0	
	Mica	45.0	50.0	50.0	5.0	80.0
	Clay min	45.0	20.0	30.0	10.0	20.0
100-mesh	Retained	3.1	1.3	2.0	5.5	1.2
mineral	Quartz	5.0	5.0	20.0	5.0	5.0
composition	Feldspar	Trace	5.0	5.0	60.0	Trace
	Mica	15.0	20.0	30.0		50.0
	Clay min.	80.0	70.0	45.0	35.0	45.0
120-mesh	Retained	2.1	1.2	1.0	3.5	1.5
mineral	Quartz	5.0	5.0	20.0	5.0	5.0
composition	Feldspar	Trace	5.0	5.0	60.0	Trace
	Mica	15.0	20.0	30.0		50.0
	Clay min.	80.0	70.0	45.0	35.0	45.0
150-mesh	Retained	1.2	0.6	0.5	3.3	1.9
mineral	Quartz	5.0	5.0	20.0	5.0	5.0
composition	Feldspar	Trace	5.0	5.0	60.0	Trace
	Mica	15.0	20.0	30.0		50.0
	Clay min.	80.0	70.0	45.0	35.0	45.0
200-mesh	Retained	3.3	2.1	2.8	5.5	2.7
mineral	Quartz	5.0	5.0	20.0	5.0	5.0
composition	Feldspar	Trace	5.0	5.0	60.0	Trace
	Mica	15.0	20.0	30.0		50.0
	Clay min.	80.0	70.0	45.0	35.0	45.0
250-mesh	Retained	1.2	0.7	0.9	3.3	0.9
mineral	Quartz	5.0	5.0	20.0	5.0	5.0
composition	Feldspar	Trace	5.0	5.0	60.0	Trace
	Mica	15.0	20.0	30.0		50.0
	Clay min.	80.0	70.0	45.0	35.0	45.0
300-mesh	Retained	1.7	2.2	2.3	4.2	2.1
mineral	Quartz	5.0	5.0	20.0	5.0	5.0
composition	Feldspar	Trace	5.0	5.0	60.0	Trace
	Mica	15.0	20.0	30.0		50.0
	Clay min.	80.0	70.0	45.0	35.0	45.0
325-mesh	Retained	1.2	0.7	0.5	1.0	0.8
mineral	Quartz	5.0	5.0	20.0	5.0	5.0
composition	Feldspar	Trace	5.0	5.0	60.0	Trace
	Mica	15.0	20.0	30.0		50.0
	Clay min.	80.0	70.0	45.0	35.0	45.0
325-mesh	Passed	26.0	13.9	24.3	34.0	26.8
mineral	Quartz	5.0	5.0	10.0	5.0	10.0
composition	Feldspar	5.0	5.0	5.0	25.0	10.0
	Mica	10.0	20.0	25.0	5.0	30.0
	Clay min.	80.0	70.0	60.0	65.0	50.0
Remarks						
Plasticity		Fair	Fair	Fair	Short	Short
Absorption (cone 14)		20.0	23.6	13.4	2.0	21.65
Fired color (cone 14)		Good white	Good white	Good white	Gray	Good white

Mineral percentages are approximate from microscopic examinations by Irma Rhode.

trip, Arthur S. Watts† estimated the available tonnage of the main deposits of Yancey, Avery, and Mitchell counties to be only 17,000,000 tons.

(2) Possibilities of a Constant Quality Product

In an attempt to answer this question, a thorough examination of the large deposits was carried on. Table III shows screen analyses and petrographic examinations of the various screen residues of fifty-one representative samples. The taking of the samples was personally supervised by the writers or a reliable representative and was done in the standard manner.[18] In the majority of cases, the average sample, after quartering, represented a ton or more of crude kaolin so that enough material was available for experimental refining work. For purposes of comparing the various samples, the material passing the 325-mesh sieve was called the "clay yield." Screen analyses were made by blunging thoroughly for one hour a kilogram of the sample on a dry-weight basis with six times its weight in water and then passing it through the various sieves. No wash water was added, as it was desired to observe the settling behavior and yields of the various screen sizes, but the retained material on the screen was washed by holding the sieve in the liquid which had passed through it and jiggling it up and down to give it an extra cleaning. The material retained on the sieve was dried, removed with a soft brush, and weighed. Samples of the residues were then examined petrographically.

A method of testing the −325-mesh claylike material was to dewater the suspension passing through the screen on a plaster slab until the material came to a normal plastic consistency. One edge of the clay was then lifted carefully by means of a hard rubber spatula, and an attempt was made to peel the clay from the slab. If the sample peeled in sheets with small tendency to break, this fact was noted, and experience later proved that this was the first indication of the more plastic type of clay. If the material did not peel from the slab but had to be scraped from it, this was taken as an indication of poor or very low plasticity. The sample was then wedged by hand in the usual accepted manner and cut with a 1.0-millimeter brass wire. If the material

† Professor of Ceramic Engineering at Ohio State University.

had a tendency to weld together, to cut without appreciable tearing, and to hold clean edges, it was regarded as having good plasticity, whereas a material which was too short to be wedged properly and left a very jagged edge upon cutting with the wire was regarded as one of poor plasticity. It is admitted that these tests are very crude and without value save as a method of comparison. With a large number of samples, however, it was possible to obtain approximately the same results from any one of four operators working independently of each other. A highly plastic Georgia kaolin was taken as a standard and, by means of the above-mentioned tests, the −325-mesh material was called plastic when the apparent plasticity or workability reached approximately 50% of that adjudged for the Georgia kaolin. Here again it was possible to obtain quite surprisingly accurate checks with several operators.

Because the amount of clay obtained by screen analysis from one kilogram was necessarily small, in the majority of cases enough clay was put through the 325-mesh screen to obtain at least 1000 grams of this product. This permitted a better sample for plasticity comparisons and also gave trials for firing. In all cases it was observed that even with the most plastic of the samples, none was obtained of sufficient quality to be used in a workable industrial body.

A rough grouping of the various clay materials obtained by screen analysis was made, giving 7 of high yield but short, 29 of high yield with good plasticity, 3 of low yield and poor plasticity, and 12 of low yield but high plasticity. Attempts to correlate microscopic examination with the physical properties of the final product gave disappointing results in practically 95% of all instances. The shortness of the clay was at first attributed to an excess of mica or feldspar, but there was sufficient evidence that the clays considered plastic might contain even more of these undesirable ingredients than the nonplastic clays. Samples from all screen residues were passed through the petrographic department and checks were run in frequent instances. The results of the checks indicated quite clearly that, within the limits of probable error, observations made with the microscope were quite correct.

One important and interesting observation, however, was made with the microscope, namely, that the material caught between the 100- or 150-mesh and 325-mesh sieves contained a considerable portion of the clay minerals, these coarser sizes being, in fact, in most cases remarkably like the mineral composition of the −325-mesh material or the clay yield. This indicated that the clay yield as obtained by blunging and screen analysis was not necessarily correct or even indicative for any given crude but that in all probability a considerable portion of clay minerals was being lost by settling out together with the feldspar, quartz, and coarser mica. It also appeared that the clay material was in the form of hard lumps, and observations indicated that these lumps or aggregates were not softer than the soft quartz or weathered feldspar, making it difficult to separate by grinding without the disruption of the feldspar particles. This would indicate that the most vital step in the refining process would be the rubbing down to the ultimate grain size of the clay clusters or aggregates unless a lower yield were to be obtained than was theoretically or practically possible. Contrary to general belief, the coarser grained or harder particles cannot be arbitrarily classified as the poorer or less plastic material. In fact, tests show that these particles can ultimately develop the greater plasticity, dry strength, and other properties.

It appeared quite evident that the question of constant quality and good working properties could not be answered by screen analyses, although it was thought that the material thus obtained had some definite value.

Observations made on the −325-mesh material indicated that it was similar in most cases to the refined North Carolina kaolin previously marketed. They also indicated a possible explanation of variation in physical properties of the commercially produced material within a deposit itself or from one deposit to another.

It was then thought that settling tests of dispersed suspensions should show clearly the differences in the −325-mesh material from different crudes showing different yields. For example, the differences in plasticity between a high- and low-yield crude might be due to fine mica, quartz, and feldspar passing through the screen, even though this was not substantiated by the microscope. Bleininger also noted in the discussion of a paper on the "Electrical Separation of Clays,"[19] that some of the clays, particularly North Carolina and Florida, were more plastic

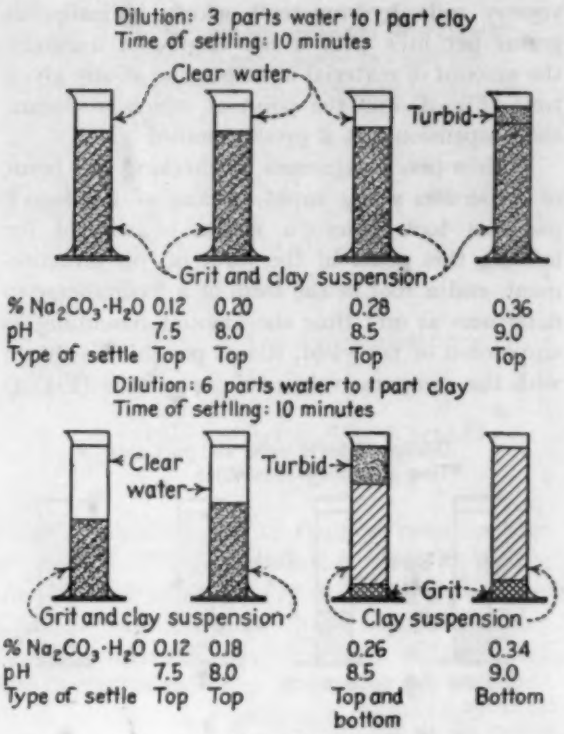
Dilution: 3 parts water to 1 part clay
Time of settling: 10 minutes
Clear water
Turbid
Grit and clay suspension
% $Na_2CO_3 \cdot H_2O$ 0.12 0.20 0.28 0.36
pH 7.5 8.0 8.5 9.0
Type of settle Top Top Top Top
Dilution: 6 parts water to 1 part clay
Time of settling: 10 minutes
Clear water
Turbid
Grit
Grit and clay suspension
Clay suspension
% $Na_2CO_3 \cdot H_2O$ 0.12 0.18 0.26 0.34
pH 7.5 8.0 8.5 9.0
Type of settle Top Top Top and bottom Bottom

FIG. 1 (*A*).

after having been deposited, even though the process of deposition made no further mineralogical separation. This showed that the increase in plasticity noted by Bleininger might have been due to the dispersion of the clay before passing the current through it and not to the deposition itself.

The dispersing of clays by the use of electrolytes, the measurement of dispersion by viscosity and hydrogen-ion concentration, and the mechanics of the reaction have been explained and dealt with by many writers.[29–40] It was felt in this case that an excess of electrolyte would be undesirable or unnecessary as that point was desired where the clay minerals would stay in suspension, and consequently a point of deflocculation and a practical means for measuring and controlling it were sought. Because of the difficulty of determining minimum viscosities in dilute suspension, the viscosity measurements were not attempted. Sodium carbonate and sodium silicate, which are commercially obtainable and easily handled, were used for dispersion. For convenience, the settling behavior of clays in dilute suspensions was called "top settle" when the whole mass tended to settle together and "bottom settle" when the heavier particles dropped out of suspension, building up a layer at the bottom and leaving the finer particles in suspension for an appreciable time. Adding the dispersing agents in small increments, either alone or in combination, slowed down the tendency to top settle. At a definite concentration and specific gravity for each electrolyte or a combination of the two, a point was reached where bottom settle definitely began. Where too little electrolyte was used, it was possible to have top and bottom settle taking place simultaneously, although top settling was considerably slowed down. Adding electrolytes in excess of amounts necessary for bottom settling slowed the settling of the dispersed clay but not enough to warrant the additional amount.

It was found that hydrogen-ion concentration measurements for either of the dispersing agents used was a successful and practical method of holding the settling behavior at a given rate. With sodium carbonate, the p_H of the suspension rose quite rapidly and continued to increase after a point of definite bottom settle was reached, as shown in Figs. 1*A*, 1*B*, and 1*C*. In the case of sodium silicate, the p_H rose until bottom settle was reached, after which point an increase was slight or none, as shown in Figs. 2*A*, 2*B*, and 2*C*.

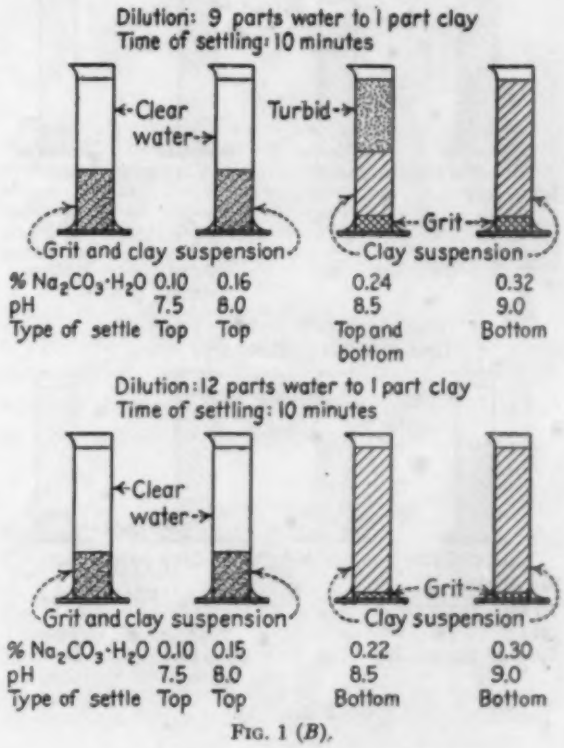
Dilution: 9 parts water to 1 part clay
Time of settling: 10 minutes
Clear water
Turbid
Grit
Grit and clay suspension
Clay suspension
% $Na_2CO_3 \cdot H_2O$ 0.10 0.16 0.24 0.32
pH 7.5 8.0 8.5 9.0
Type of settle Top Top Top and bottom Bottom
Dilution: 12 parts water to 1 part clay
Time of settling: 10 minutes
Clear water
Grit
Grit and clay suspension
Clay suspension
% $Na_2CO_3 \cdot H_2O$ 0.10 0.15 0.22 0.30
pH 7.5 8.0 8.5 9.0
Type of settle Top Top Bottom Bottom

FIG. 1 (*B*).

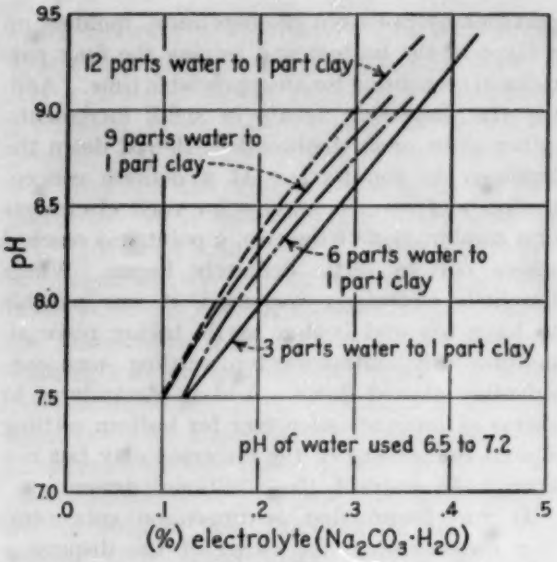

FIG. 1 (*C*).

Measurements of the p_H were taken electrically and by the colorimetric method, and the results checked closely, provided that the suspension was filtered in the case of the colorimetric. Settling tests were accordingly made, using the Bou-

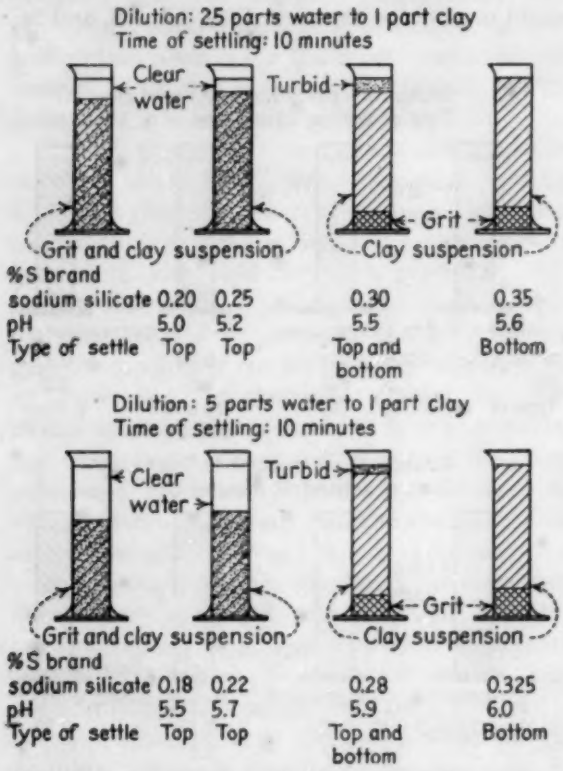
Dilution: 25 parts water to 1 part clay
Time of settling: 10 minutes
Clear water
Turbid
Grit
Grit and clay suspension
Clay suspension
%S brand
sodium silicate 0.20 0.25 0.30 0.35
pH 5.0 5.2 5.5 5.6
Type of settle Top Top Top and bottom Bottom
Dilution: 5 parts water to 1 part clay
Time of settling: 10 minutes
Clear water
Turbid
Grit
Grit and clay suspension
Clay suspension
%S brand
sodium silicate 0.18 0.22 0.28 0.325
pH 5.5 5.7 5.9 6.0
Type of settle Top Top Top and bottom Bottom

FIG. 2 (*A*).

youcos soils hydrometer[41] which indicates in grams per liter with a fair degree of accuracy the amount of material in suspension at any given time (Fig. 3) and the point at which to decant the suspension for a predetermined yield.

With a practical means of checking the point of dispersion where rapid settling of the heavy particles took place, a means of control for holding this point in the form of p_H measurement, and a tool in the form of a hydrometer to determine at any time the amount remaining in suspension or the yield, it was possible to obtain with the comparatively crude apparatus (Fig. 4)

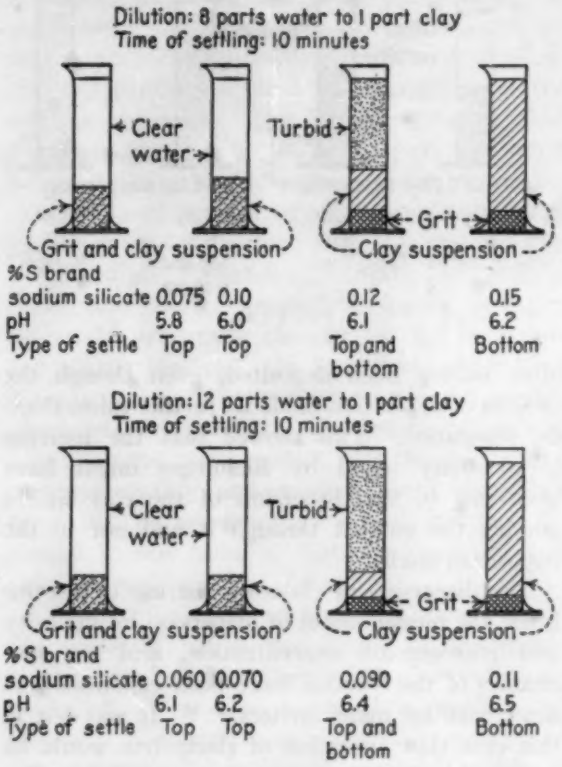
Dilution: 8 parts water to 1 part clay
Time of settling: 10 minutes
Clear water
Turbid
Grit
Grit and clay suspension
Clay suspension
%S brand
sodium silicate 0.075 0.10 0.12 0.15
pH 5.8 6.0 6.1 6.2
Type of settle Top Top Top and bottom Bottom
Dilution: 12 parts water to 1 part clay
Time of settling: 10 minutes
Clear water
Turbid
Grit
Grit and clay suspension
Clay suspension
%S brand
sodium silicate 0.060 0.070 0.090 0.11
pH 6.1 6.2 6.4 6.5
Type of settle Top Top Top and bottom Bottom

FIG. 2 (*B*).

a refined clay of good characteristics thought at least indicative of that which would be obtained on a larger scale. Since, as previously observed by screen analysis, the yield of clay-like material through 325-mesh varied within fairly wide limits, not only from one part of a given deposit to another but also between different deposits, trials were made, first, by using an average crude which was a mixture of various samples and refining it to give a yield of approximately 15%, and second, by refining the same crude to different

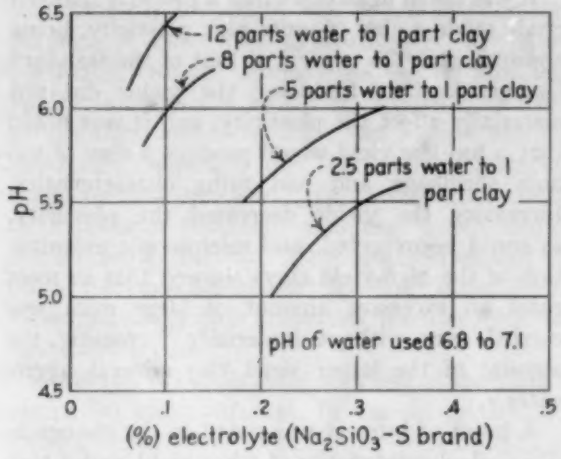

FIG. 2 (*C*).

yields to obtain a clay of the best possible characteristics. Trials were further made by mixing the different types of clay occurring in one deposit in approximately that proportion which could be commercially produced in the same mine. It appeared to be definitely indicated by these trials that, although the yields of clay would thus vary in amounts from one deposit to the other, an average high yield for each deposit would have the same general physical characteristics. By observing the results obtained from a screen analysis of such average crudes, together with observations made upon the settling curve of the −325-mesh material, it became possible to predict within very close limits the amount which could be refined to meet a certain definite specification. For example, referring to the curves shown in Fig. 5, a yield of

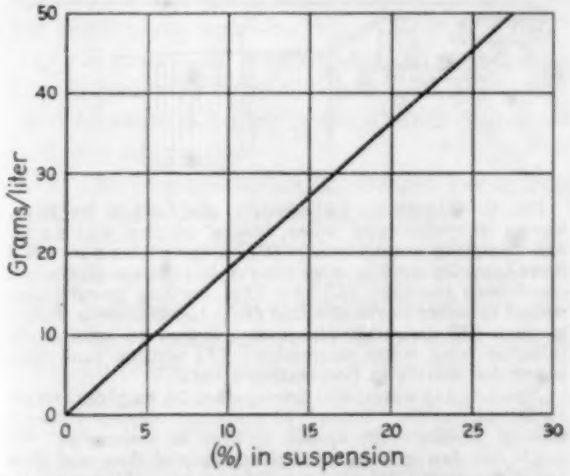

FIG. 3.—Hydrometer reading to percentage for suspensions having 6 parts water to 1 part clay.

24% could be obtained in clay No. 1, approximately 15% in clays Nos. 2 and 3, and 12% in clay No. 4. These clays, with the exception of one obtained from a crude very high in weathered feldspar, were close as to plasticity, dry strength, shrinkage, absorption, fired color, and fired shrinkage. The clay high in feldspar, when refined to a high yield, was also similar with the exception of the fired shrinkage and absorption,

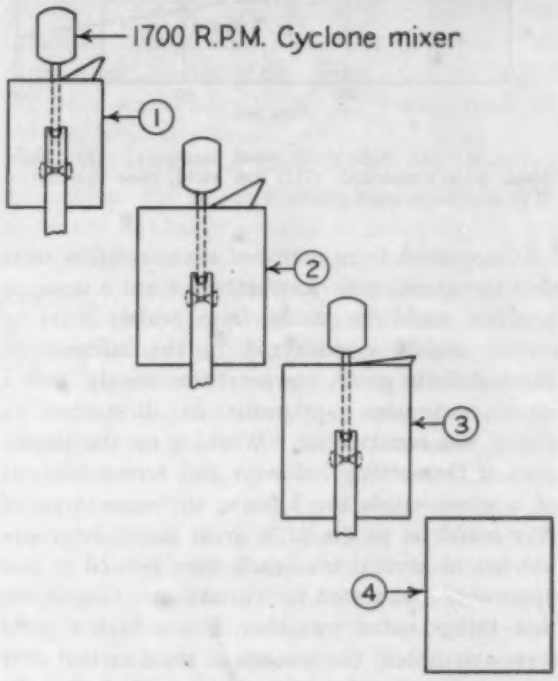

FIG. 4.—(1) Water, 40 liters; clay, 5 kg.; blunge 45 min.; settle 1 min.; decant effluent; discard residue. (2) Add 60 liters of water; add electrolyte to bottom settle and blunge 15 min.; settle to desired hydrometer reading and decant; discard residue. (3) Screen through 325-mesh and, if necessary, settle and decant again. (4) Flocculate, settle, and syphon off clear water.

which is to be expected with a clay containing a considerable portion of fine feldspar that is also conceivably acted upon by the electrolytes. Average physical characteristics of the two types of clay are given as follows:

	Type 1 (low feldspar)	Type 2 (high feldspar)
Residue on 200-mesh	Trace	Trace
Plasticity	Good	Good
Water of plasticity	35.2%	35.6%
Drying shrinkage	3.75%	3.90%
Drying behavior	Very good	Very good
Transverse dry strength	110 lb./sq. in.	118 lb./sq. in.
Fired shrinkage, reducing conditions (cone 14)	10.3%	13.7%
Absorption (cone 14)	12.0%	1.5%
Fired color	Good white	Good white

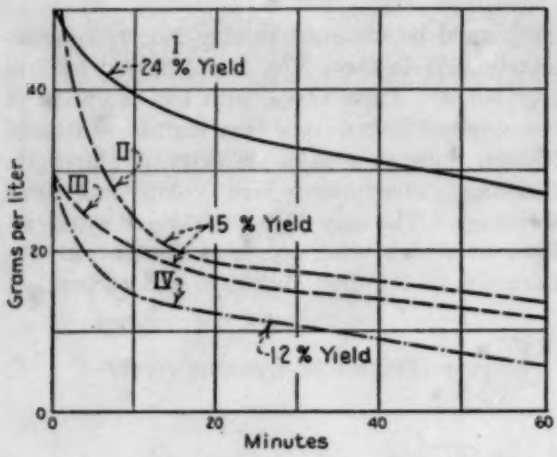

FIG. 5.—(I) High yield, good plasticity; (II) high yield, poor plasticity; (III) low yield, poor plasticity; (IV) low yield, good plasticity.

It appeared from many of these refining tests that the question as to whether or not a uniform product could be made from widely varying crudes could be answered in the affirmative. More definite proof, however, was sought, and a more continuous apparatus as illustrated in Fig. 6 was constructed. Working on the theory that, if the settling behavior and screen analysis of a given crude are known, the same type of clay could be produced, a great many large-size batches of several tons each were refined in this apparatus and tested for variations. One of the first things noted was that, if too high a yield were attempted, the amount of mica carried over through the trough was excessive. Reducing the yield caused an appreciable loss in otherwise usable clay material through the mechanical separation or the dragging down of the mica and other materials. Consequently, it was assumed that a properly built refinery could obtain yields at least 2 to 3% higher than those obtained in the laboratory apparatus. This figure can probably be further raised at least 5% with proper machines for reducing the clay minerals occurring in the form of large-size aggregates which tend to settle out with the feldspar, quartz, and coarse mica. Results from many of these tests, using batches of one or more tons of crude, indicated that the assumption was apparently correct, inasmuch as clays of the same characteristics as formerly noted were produced from crudes having widely varying clay yields and settling characteristics as shown by the screen analyses and settling curves.

It was noted in all cases that a properly handled crude made a clay of quite high plasticity, being approximately 75 to 80% of that of the standard Georgia kaolin. Reducing the yields did not materially affect the plasticity, and it was noted that a too low yield would produce a clay of too high shrinkage and bad firing characteristics. Increasing the yields decreased the plasticity, as could be expected, and microscopic examination of the high-yield clays showed that in most cases an excessive amount of large mica was carried over without materially increasing the amount of the larger sized clay-mineral aggregates.

A point of interest was noted in the change in physical characteristics of a low yield and a high yield from the same crude by grinding in a ball mill. The low-yield, very fine (7 to 10%) material did not react with grinding to any appreciable extent, but when the yields amounting to 20 to 25% from the same crude were ground for twelve hours, a highly plastic clay was obtained. This suggested the possibility of the use of higher yields by grinding, and attempts were made to use a colloid mill for this purpose. The material

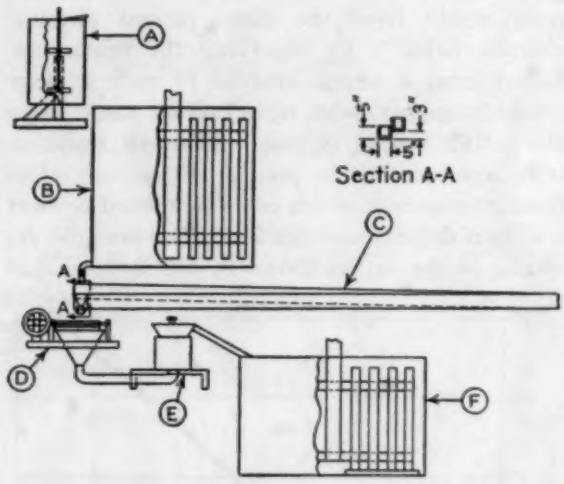

FIG. 6.—*Machines:* (*A*) blunger, zinc tank 21 by 26 in. having propeller-type mixer blades turning 500 r.p.m. and decanting arrangement; (*B*) blunger, 100 r.p.m. 800 liters capacity used to store reserve to insure uniform and continuous running; (*C*) two 12-ft. settling troughs connected in series to remove fine grit; (*D*) 300-mesh shaker screen; (*E*) magnetic separator adapted to remove Fe minerals from water suspension; (*F*) settling tank with sweep for stirring in flocculating agents.

Process: (1) water, 100 liters; clay, 25 kg.; electrolyte to bottom settle; blunge 10 minutes; decant effluent; discard residue. (2) agitate to keep in suspension; (3) settle out fine grit by controlling rate of flow and final specific gravity; (4) screen out fine mica; (5) remove Fe minerals, (6) flocculate and settle, pump off clear water.

processed in the colloid mill by passing the slip through it twice had approximately the same plasticity and dry strength as that ground for twelve hours in the ball mill but with the surprising difference of retaining an almost normal shrinkage, whereas the ball-milled material shrinkage had increased quite markedly, as could be expected. Although this experiment could not be called practical, it nevertheless tended to prove the supposition that the large clay aggregates had many fine properties when reduced to individual grains.

Tests run in coöperation with one of the kaolin companies indicated that, by the old method of refining described by Watts,[9] they were obtaining a yield of not higher than 10%. It was consequently believed that, as the use of electrolytes apparently increased this percentage a possible 5% of the crude, the extra costs of refining in a modern plant should be very nearly compensated for. Fortunately, the crude kaolins contain 5 to 10% of fine white mica which also has a market value, making possible the transfer of part of the refining costs from the kaolin to it. The actual commercial yield obtained will naturally vary with the type of refining used, the care and control excercised, and the type of primary blunging done; consequently, no prediction can be made at this time.

The question as to the possible substitution of a properly refined North Carolina kaolin for English clay is dealt with in Part IV of this investigation.

IV. Conclusions

From the foregoing investigation, the following conclusions were drawn:

(1) A reserve of North Carolina crude kaolin is now known to be of sufficient quantity to last the whiteware industry of the United States for well over 100 years.

(2) The North Carolina kaolins are low in iron content and practically free from TiO_2.

(3) A kaolin of good physical characteristics and fine fired color can be produced from the crude material. This refined material gives indications of being workable in ceramic bodies.

(4) Although the amounts of clay-like material vary within a deposit and from one deposit to another, the physical characteristics of clays which can be refined from many given deposits are similar.

(5) A judicious mixing of all types of crudes within a deposit is necessary for continuous beneficiation.

(6) The use of electrolytes makes possible an operation which was difficult or impossible by the mechanical method described by Watts[9] and is not basically changed today.

(7) It is believed that a continuous process could easily be devised whereby the speed of a suspension, controlled both as to p_H and specific gravity, could be regulated to drop out the undesirable constituents and save practically all of the workable materials. Such a process should not have appreciably higher labor costs than the old mechanical process.

(8) The control of the specific gravity of the suspension, its p_H, and the time of settling is necessary but easily possible to maintain.

(9) The amount of electrolyte required for dispersion is affected both by the amount of clay to be dispersed and the dilution, but the clay appears to have decidedly more effect.

(10) Results of the foregoing tests indicate that an average yield of 10 to 15% or higher can be obtained from the North Carolina crudes. With the addition of 10% mica as a by-product, it then becomes possible to base refining costs on an approximate 20 to 25% yield of pay material.

(11) It is realized that results obtained, indicating a probable uniform product which could be produced, must be checked in actual production. A well-run modern plant having an excess of storage capacity for the clay in the slip as well as in dried form should eliminate any small variations encountered during the refining process or from the raw material itself.

(12) The foregoing experiments were centered largely upon one type of refining which appeared practical. It was evident that separations with the use of electrolytes could be done in other ways with a probable different and perhaps better product.

(13) Experiments carried on by the Bureau of Mines on the same crudes by the use of froth flotation indicate that this method of refining has great possibilities for the almost complete separation of the clay-like material from the feldspar.

(14) More scientific measurements were not taken upon the material refined in the laboratory for the reason that it was felt that refining done on a small scale would not be as indicative as that done on a commercial basis, and conse-

quently these were postponed until such commercial clays were available.

(15) From observations as to settling and clay tests, it could be concluded that the kaolin refined by the use of electrolytes, as described, contained an appreciably higher percentage of fine or colloidal material than the samples previously worked on by other investigators. This is thought to be because of the freeing of finer grains formerly held by the larger masses or aggregates and also because the old mechanical method of refining wastes a considerable portion of the fines in the washing process.

(16) It is believed that the addition of a fine-grained, white-firing clay, such as Florida kaolin, will make a mixture suitable for substitution for English kaolins in whiteware bodies. The drying character of all clays described above was very good, and twisting and cracking during drying, even under he most severe conditions, was never noted.

(17) When the better-refined and more closely controlled North Carolina clays are commercially produced, it is believed that they will be worthy of consideration by the entire whiteware industry.

(18) One of the most important operations in the refining process appears to be the primary blunging and reduction of the large-size clay aggregates. This part of the process deserves much special study, inasmuch as a reduction of the coarse particles not only increases the yield but also will probably deliver a material of good physical characteristics.

(19) While the microscope could not explain differences in physical properties by mineralogical analysis, it nevertheless was a good aid in prospecting and a supplement to the screen analysis.

PART IV, DEVELOPMENT OF A TRUE PORCELAIN OR CHINA-TYPE VITREOUS DINNERWARE BODY USING AMERICAN MATERIALS

By R. E. Gould and A. J. Hedquist

Abstract

Specifications are given for an improved body of the true porcelain or china type to include as many as possible of the desirable characteristics without increasing materially the production costs.

Steps in the development of such a body are described. The resultant composition appears to meet the specifications in nearly all cases.

I. Introduction

As seen from Part III of this investigation, it appears possible to produce a kaolin of fairly good plasticity and dry strength from the primary kaolin crudes of North Carolina. Since this kaolin fires to a good white color, has apparently a long firing range, is relatively low in iron, and contains practically no titanium oxide, it should not only be usable in vitreous whiteware in general but should also make possible the development of a superior type of thin, vitreous dinnerware, either of the china or true porcelain type. Riddle and McDanel[3] have noted that three ways of procuring a good white color in a vitreous dinnerware body are (1) using very pure materials, (2) firing the body under reducing conditions, and (3) firing the body in an oxidizing atmosphere and masking the yellowish color by the addition of a blue stain.

It appears that combining the use of pure materials with firing in a reducing atmosphere should produce a body of exceptional white color, if white is desired, or a base for colored bodies not contaminated with undesirable blue-gray or yellowish tints.

It is also thought that using the North Carolina kaolin as the principal plastic constituent in a vitreous dinnerware body should be a severe test of the kaolin.

It was decided to attempt the development of a type of dinnerware which would include as many as possible of the good characteristics of the various types now being made and marketed. Furthermore, it is believed that the basic production costs in making high-quality, thin, vitreous dinnerware are too high and make it difficult for this branch of the ceramic trade to follow the trend of general lowering of price with steadily rising quality, which is so apparent in practically all other lines of merchandise. Therefore

it was decided to attempt to confine each operation to a prescribed known cost limit so that the ultimate sales price, if such a ware were successful and could be manufactured, would not be appreciably higher than the better semivitreous ware being marketed today. Watts[42] has described and discussed the various types of dinnerware now being marketed and has pointed out the good and bad features of each. Table I shows some of the characteristics of the various types of ware from which the desirable properties and costs can be drawn as limits for the proposed product. Assuming that a body can be compounded using the North Carolina kaolin, which should give an excellent white color and high degree of translucency, both properties approaching or equaling those of bone china or Belleek ware, the following characteristics would be desirable: (1) body materials costing not more than the hotel china type, (2) working properties as good as semivitreous or hotel china, (3) normal shrinkage with possibilities of regulation within a fairly wide range so that present models and dies could be used, (4) uniform plasticity and other working properties, such as dry strength, to permit its forming as rapidly as semivitreous or hotel china, either by hand or automatically, (5) a bisque-kiln fill equal to or better than semivitreous or hotel china, (6) possibilities of using underglaze decoration as good as hotel china or semivitreous, (7) a glaze as hard as (or preferably harder) than hotel china and as smooth and brilliant in appearance, (8) the possibility of glost placing and and firing as cheap as semivitreous, and (9) toughness of the finished body equal to or better than hotel china.

It may be seen that the above specifications limit the composition of the body as well as each operation within fairly narrow ranges.

TABLE I

	Semivitreous	Hotel china	True porcelain	Bone china	Belleek
Body cost	Very cheap	Fairly cheap	Fairly cheap	Expensive	Very expensive
Working properties of body	Very good	Good	Fairly good	Poor	Very poor
Bisque fire					
Temperature	Cones 9–10	Cones 10–12	Cones 011–09	Cones 9–10	Cones 3–6
Atmosphere	Oxidizing	Oxidizing	Oxidizing	Oxidizing	Oxidizing
Bisque-kiln fill	Good	Good	Good	Very poor	Very poor
Glaze					
Cost	Expensive	Expensive	Cheap	Expensive	Expensive
Appearance	Good	Good	Fairly good	Good	Very good
Glost fire					
Temperature	Cones 3–6	Cones 3–6	Cones 12–14	Cones 2–3	Cones 02–1
Fill	Good	Good	Very poor	Fair	Poor
Color of finished body	Only fair, blue-white to ivory	Gray - white or colored	White or ivory	Good white	Very good ivory
Translucency	None	Weak and cloudy	Fair	Good	Very good
Decoration	Over- or underglaze	Over- or underglaze	Overglaze with little underglaze	Over- or underglaze	Over- or underglaze
Remarks	Forms very fast, high dry strength, rather slow bisque fire due to high ball clay, glaze soft	Works good, is fairly fast, danger of overfire, very tough finished body, good decorating possibilities, usually made in heavy ware, fairly hard glaze	Good ware, requires slow working and highly skilled labor, final glaze very hard	Works very slow, requires high degree of skill, finished body very tough, excellent white color, very soft glaze	Works very slow, requires highly skilled labor, glaze too soft for hard service, very beautiful ware

II. Procedure

First trials were made using a composition of an average true porcelain, North Carolina kaolin 50%, feldspar 25%, and quartz 25%. This body appeared to work fairly well, but the dry strength of 100 pounds per square inch and the plasticity were far below that of a good hotel china body.

It was thought that the addition of a good light-firing ball clay would improve this feature, and several American ball clays were tried by adding them at the expense of kaolin in increments of 2% up to a total of 10%. It was found that 4 to 6% of a light-firing Kentucky ball clay increased the dry strength up to about 200 pounds per square inch, provided the body was put through a vacuum pug mill, and the plasticity

was improved to a surprising degree, although it was still not enough for good working. Further additions of ball clay up to 10% did not materially improve the plasticity, although the dry strength rose proportionally. Trials made of this body, fired in an oxidizing or reducing atmosphere to cone 14 in six hours, showed that while the color was fair the translucency suffered greatly with increased ball clay, the bodies containing 10% being murky and almost opaque. Results of these tests indicated that ball clay should not be added in amounts of more than 2 or 3% if the color and translucency of the fired body were to approach those of bone china and Belleek.

Grinding the bodies for a minimum of six hours in a ball mill improved the working properties of those containing 4% ball clay to the point where they were considered fairly passable. This type of body preparation, however, is more expensive in regard to labor and machinery investment than blunging, as is done with semivitreous bodies, so that ball milling was discontinued.

Trials were then made by adding Florida and Georgia kaolins individually and in equal parts at the expense of North Carolina kaolin, using the same increments as were used with the ball clays. It was found that the introduction of Georgia kaolin harmed the color and decreased the translucency of the fired body, being worse in this respect than ball clay. Florida kaolin alone improved the plasticity and dry strength of the body to a surprising degree, and the addition of 12% produced a body which indicated good working properties and a passable dry strength of about 350 pounds per square inch. Increasing the Florida kaolin over this amount did not improve the modulus of rupture and increased the shrinkage and tendency to twist. Trials for firing up to this point had been made by forming disks and comparing the color and translucency with a good piece of standard porcelain.

It was found that, surprisingly, the bodies containing all North Carolina kaolin were not so good as to color and translucency as those containing 10% Florida kaolin unless the maturing temperature of the former was raised at least two cones. For better trials as well as for obtaining an indication as to the casting qualities of these bodies, trials were made into casting slips, and small vases were used as test pieces.

North Carolina kaolin has been reported as a bad casting clay, and the difficulties encountered before obtaining a good-working casting slip are described in Part V of this investigation. When firing trials were made following the procedure used in true porcelain, *i.e.*, a cone 010 bisque and cone 14 glost, it was noted that the speed of firing could not be carried to the maximum unless the last part of the operation was slowed down.[43] Leaving off the glaze resulted in good clear bodies of excellent color which were good on quite fast-firing schedules. As no very serious thought had been given to the development of true porcelain, owing to its poor kiln fill and the necessity for highly skilled workers, this was not disappointing until attempts were made to glaze the high-temperature bisque pieces of the true porcelain composition. All of the glazes tried crazed badly, even though the theoretical thermal coefficient of expansion of the glaze was reduced as much as possible without lessening the brilliancy. Analysis of the total silica of this body showed 65%.

Although the translucency of the above trials indicated it to be very good, being a clear white, it was nevertheless hoped to improve this feature to bring it to the desired prescribed degree. Accordingly, bodies were made by increasing the feldspar at the expense of flint in 2% intervals up to a maximum of 50%. A series of these bodies fired together to cone 14 under reducing conditions indicated that the translucency increased up to 33% feldspar and remained approximately constant thereafter up to 50%. Trials were then made reducing the amount of clay substance, and it was found that 40 to 44%, as calculated by the Berdel[44] method, showed the best results. It was found in reducing the clay substance that this should be at the expense of the North Carolina kaolin, as a proportional decrease in the Florida kaolin too seriously injured the plasticity and other working properties. A body of good translucency could be made by combining the increase in feldspar and decrease in clay substance and by reducing the quartz, giving a composition of North Carolina kaolin 32%, Florida kaolin 10%, feldspar 40%, and flint 18%.

This body gave indications of working quite well, had a good white color, high degree of white translucency, the ability to withstand the thermal shocks of fast firing and cooling, and could be made either by the true porcelain method of

firing body and glaze together or to high bisque without the glaze, followed by a lower temperature glost fire. When glazed, the hollow ware gave no trouble, but flat ware tended to craze, especially where the glaze was heavy. Although no actual measurements were taken, it was noted that the toughness of the finished product was no greater than that of true porcelain and was definitely lower than hotel china, bone china, or Belleek. It was also apparent that the costs of body materials using a high percentage of feldspar would be excessive and over the prescribed limit. A typical hotel china body of the following composition was then made for firing to cone 10 down:

	(%)		(%)
Flint	38	Florida kaolin	5
Feldspar	15	Ball clay	15
North Carolina kaolin	26	Whiting	1

Only after many attempts was a firing schedule found which would produce a body of a fair degree of translucency and color. Fired under oxidizing conditions, this body, as well as modifications of it by eliminating the ball clay, appeared to be as good as the average, and a fair white color could be produced with the addition of a small amount of cobalt sulfate. The translucency of the bodies fired in an oxidizing atmosphere was very poor, being of low degree and dark color. Those fired under reducing conditions were fair, having a translucency of a slight greenish tinge. It was noted also that speeding up the firing schedule to that successful in making the high-fired porcelain resulted in a grayish to black product in each case. This was attributed to the enclosure of carbon from the carbon monoxide atmosphere in the ware due to the too early fusion of the body. The ware fired under oxidizing conditions was rejected because of its poor color and translucency. Even the best-fired ware under reducing conditions did not meet the set standard by a wide margin.

Believing that too early vitrification was the cause of the grayish color, the fluxes were reduced until the body became mature at the true porcelain temperature of cones 13 or 14. It was believed also that the rules in regard to total silica in the body would be approximately the same as those applying to semivitreous ware, and consequently this figure was kept at 68% or above. The resultant body had the following composition:

Body composition	(%)
North Carolina kaolin	33
Florida kaolin	10
Feldspar	20
Quartz	35
Dolomite	2
Physical properties	
Plasticity	Good
Water of plasticity	24.4%
Drying shrinkage	3.20%
Transverse dry strength	350 lb./sq. in.
Fired shrinkage, cone 14	8.0%
Total shrinkage	11.2%
Drying behavior	Very good
Fired color (cone 14) reducing atmosphere	Good white
Texture	Slightly grainy
Total silica (SiO_2)	68.42%

When fired as true porcelain, the bisque at cone 010 was glazed with a raw glaze having the following molecular formula:

$$\left.\begin{matrix}0.300\ K_2O \\ .350\ CaO \\ .350\ MgO\end{matrix}\right\} 0.950\ Al_2O_3 \quad 9.500\ SiO_2$$

Treated as china, the bisque was fired at cone 14 under reducing conditions, and the ware was glazed with a fritted glaze for a cone 5 to 7 glost having the following molecular composition*:

$$\left.\begin{matrix}0.0545\ KNaO \\ .4455\ PbO \\ .5000\ CaO\end{matrix}\right\} 0.2700\ Al_2O_3 \left\{\begin{matrix}2.7000\ SiO_2 \\ 0.3203\ B_2O_3\end{matrix}\right.$$

Batches of 1000 pounds each were made of the body, which permitted its passage through a vacuum pug mill. It was surprising to note the enormous increase in plasticity and proportional increase in dry strength over the hand-wedged samples, which in every case were approximately doubled. The body was not quite as plastic as the average semivitreous body but was slightly better than an average good hotel china body. Jiggering hollow and flat ware, as well as pressing such articles as bakers, steak dishes, etc., showed that the body could be worked slightly easier than the hotel china and almost as easily as the semivitreous. It was found in the meantime, as reported in Part V, that the casting behavior of such a composition was also as good as the average hotel china body and slightly better than semivitreous high ball-clay types. The average dry strength of 350 pounds per square inch for plastic-formed ware and a somewhat greater strength for cast ware should be ample against breakage, provided reasonable care is taken and the variations are slight. A method for producing straight flat ware is dealt with in Part VI.

* A more intensive study of glazes in respect to composition and physical properties is planned for a later date

This body was prepared by grinding the dolomite with 7.5% of the North Carolina kaolin with water for 18 hours and adding this mixture in the blunger to the other body ingredients. It was then screened through 140-mesh and 12XX-silk lawn, passed over a strong magnet, and filter-pressed at a finishing pressure of 140 pounds. It is noted that the filter-pressing was quite rapid, as could be expected, and that the filter cakes were firm and well filled out. These cakes were then passed through the pug mill under a vacuum of 27 inches of mercury and stored in a damp cellar for one or two days or used directly after a second pugging. Both jiggered and cast bodies dried extremely well and, as stated before, could be fired quite rapidly. The experimental firing schedules found suitable for hollow and flat ware are given in Part VII.

III. Conclusions

(1) This investigation checked results of previous investigators that ball clay injures color and translucency to a marked degree and, if used, must be held to an absolute minimum.

(2) North Carolina kaolin, when used as the principal plastic constituent, permits the addition of Florida kaolin in amounts large enough to give the required dry strength and to aid plasticity without the undesirable characteristics of excessive shrinkage and tendency to warp and dry-crack. A controllable modulus of rupture of 350 pounds per square inch is easily reached without appreciable detriment to the color.

(3) The use of clays containing high percentages of iron and titanium oxides such as Georgia kaolins is also detrimental to color and translucency.

(4) In this investigation, the problem of vitrification due to the more refractory nature of American clays was met by increasing the firing temperature. In this particular case, the adjustment is thought to be an advantage, as the net result indicates a greater flexibility in firing schedules and less tendency to become dark; it also produces a more resistant body, indicating the possibility of using a hard glaze with a good kiln fill if the china method is followed.

(5) The best body developed indicated that the prescribed limits as to costs, speed of working, etc., can be nearly met in all instances.

(6) The body and method of treatment indicate that the final product is a cross between true porcelain and hotel china. Since no standard definition exists for either kind of ware, it is possible to put in into either category, *i.e.*, it is a true porcelain body fired as china or it is a china-body bisque fired to a true porcelain temperature under reducing conditions.

(7) A reducing atmosphere is most effective on all-kaolin bodies of low titanium content. If ball clays and kaolins high in titanium are employed, the effect of a reducing atmosphere is very small, and the firing must be done slowly to have even a surface effect.

(8) The bodies used may be processed either by the true porcelain or by the china method.

(9) Further development work on bodies of this type, together with more exact data as to costs and physical properties, will follow at a later date.

PART V, NOTES ON CASTING ALL-KAOLIN BODIES OF TRUE PORCELAIN AND CHINA TYPES

By A. J. Hedquist, R. E. Gould, and E. W. Wilson

Abstract

A description is given of the methods used in casting bodies in which the clay content consists of North Carolina and Florida kaolins and of the effect of various electrolytes on this type of body. The trouble was found to lie in the type of electrolyte used. Sodium carbonate and sodium silicate were unsuccessful, but sodium tannate and sodium gallate and various organic dispersing agents produced casting slips which appeared to have excellent commercial possibilities.

I. Introduction

Bodies of acceptable plasticity, color, translucency, dry strength, etc., were successully made as described in Part IV but, as noted there, the casting behavior was extremely poor. Since good casting is a very necessary property of a practical body, an investigation was started to determine whether these bodies could be made to behave as well as hotel china or semiporcelain.

II. Procedure

(1) Experiments with Sodium Carbonate and Sodium Silicate as Electrolytes

Because sodium silicate and sodium carbonate are the electrolytes most commonly used in practice, all first trials were made with them. The best body had the following composition:

Batch composition	(%)	As calculated from rational analysis*	(%)
N. C. kaolin	33	Clay substance	40
Florida kaolin	10	Feldspar	21.5
Feldspar	20	Quartz	36.5
Quartz	35	Dolomite	2
Dolomite	2		

* The above formula is given on the basis of a rational analysis by the Berdel method because at the time of writing the source of North Carolina kaolin has not been commercially stabilized, and different methods of refining can produce clays of more or less feldspar. Adjustment to the above basis by rational analysis will give constant results.

Variations in the composition using the above ingredients did not appear to affect materially the casting behavior of the body, *i.e.*, substituting either of the kaolins for the other, increasing the feldspar at the expense of quartz with the elimination of dolomite, etc., appeared to have little or no effect. These bodies, when made up into casting slip in the usual manner and dispersed with varying amounts of sodium silicate or sodium carbonate or a combination of the two, all had the same following general properties: (1) It was difficult to obtain and hold a slip of specific gravity higher than 1.70, (2) the casting was abnormally fast, (3) the cast did not release from the mold, (4) the draining was very poor, and (5) the body felt very short and could not be easily trimmed.

Lowering the specific gravity to obtain a lower viscosity improved the draining but greatly magnified all of the other faults.

Although it was known that the substitution of other types of clay would result in a finished product of lower quality, nevertheless trials were made, as it was thought that if the bodies would work successfully, some insight into the poor casting qualities of the North Carolina and Florida kaolins could be gained. Accordingly bodies were made up (1) by substituting American ball clays in increments of 2% for the Florida or North Carolina kaolins, (2) by substituting good casting English china clays for the North Carolina china clay, and (3) by introducing a fine-grained Georgia kaolin at the expense of North Carolina or Florida kaolins. An improvement in casting was noted in practically all cases. The minimum amount of ball clay which could be used was found to be 5%. The introduction of English china clay proved best when this amount equalled one-third of the total kaolin content. The introduction of the fine-grained Georgia paper clay made a workable casting slip when this was in the amount of 30% of the clay content. With the exception of the bodies containing English china clay, the finished product in all cases was poor, suffering greatly in color and translucency, the quality decreasing in direct proportion to the amount of the clays added. The bodies containing the English china clays, although not so good as the standard, were still quite acceptable.

It was then thought that the reason for the poor casting of the bodies might be the lack of sufficient colloidal material in the North Carolina

kaolin, and trials were made by pregrinding this kaolin with water in a ball mill for different periods of time. It was found after a minimum grind of six hours that the resulting body cast quite satisfactorily, using either sodium silicate or sodium carbonate or a combination of the two. The grinding of kaolin is generally considered to be dangerous, and the cost of this method of body preparation is much higher than the usual procedure of blunging. Grinding the kaolin increased the firing shrinkage slightly, and it is believed that the tendency to absorb strains in the manufacturing process was increased. Consequently, this method of procedure was considered rather impractical and worthy of use only as a last resort.

Various organic colloids, such as agar-agar, glycerine, gluten, and various flours, were added to the casting slip in very small increments with the hope that these would improve the casting behavior of the body. It was noted that some slight improvement in the release from the molds and in trimming was obtained with flour, agar-agar, and glycerine. The slips, even when working best, could not be considered practical in any manner. In all cases, jelling was observed a very few moments after agitation stopped.

Varying the hardness of the molds from the extremely soft mixtures to the very hardest did not have any beneficial effect upon the casting behavior. It was noted that the extremely hard mixes showed many pinholes on the surface next to the mold, which bears out an observation by Hall.[45]

The size of the trial batches mentioned above varied from 25 to 100 pounds. All casts were made by a journeyman caster whose thirty years of experience in the vitreous and semivitreous fields should qualify him to pass expert judgment. The pieces attempted are shown in Fig. 1. In the trials mentioned so far, it was possible to make only Nos. 1, 4, and 7 without excessive losses sometimes amounting to 100%.

FIG. 1.

No.		Mold loaned by
6	Teapot	Hall China Co.
8	Cream jug	Homer Laughlin China Co.
11	Cream and sugar	Mayer China Co.
12	Cream, sugar, teapot	Taylor, Smith, & Taylor Co.
13	Cream and sugar	Edwin M. Knowles China Co.
14	Cream and sugar	Homer Laughlin China Co.
16	Baker	Homer Laughlin China Co.

Other pieces molded at the TVA Ceramic Laboratory.

The above work covered a field of more than 200 body compositions using North Carolina and Florida kaolins, including the additions of ball clay and other clays mentioned previously, and more than 500 attempts to make these into successful casting slips. Other possible factors entering into the situation such as temperature, length of agitation, method of preparation of the body, etc., were also closely studied to be

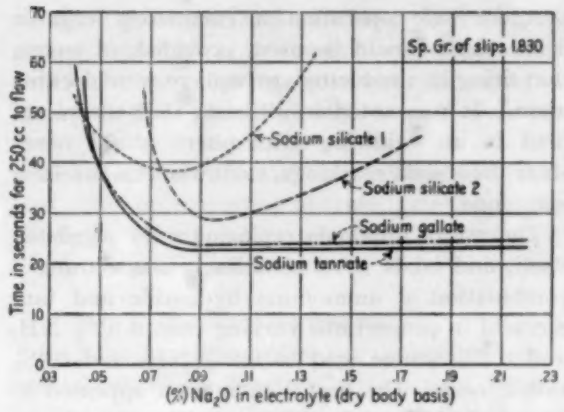
Sp. Gr. of slips 1.830
Sodium silicate 1
Sodium silicate 2
Sodium gallate
Sodium tannate
Time in seconds for 250 cc to flow
(%) Na_2O in electrolyte (dry body basis)

FIG. 2.

sure that no minor point causing the difficulty was overlooked.

It was concluded at this point that a different approach to the problem would have to be found if the desired body composition were to be cast successfully and practically. It appeared that either sodium carbonate or sodium silicate or both were improper electrolytes or that the bodies made from the clays could not be cast successfully.

(2) Experiments with Different Types of Electrolytes

A review of the literature as covered by Hall[45] failed to reveal any exact reason for the failure of sodium carbonate and sodium silicate to work practically and satisfactorily. Webb[46] noted that bodies low in protective colloids would be slow to react with sodium carbonate, a fact which this investigation apparently confirms. Webb further stated that bodies low in plasticity react best with electrolytes yielding protective colloids on hydrolysis. Schramm and Hall[47] state that gallic and tannic acids act as protective colloids.

Trials made using sodium tannate and sodium gallate as dispersing agents were immediately successful. It was noted that the actions of both were similar and that by their use very fluid slips of high specific gravity were obtainable. Slips thus dispersed and properly prepared cast extremely well, drained excellently, released from the molds, and were very tough in the leather hard and dry states. Typical viscosity curves of sodium tannate and sodium gallate, compared with two sodium silicates, marked No. 1 and No. 2, are given in Fig. 2. Number 1 sodium silicate contains 8.85% Na_2O, and the ratio of Na_2O to SiO_2 is 1:3.22; No. 2 sodium silicate contains 11.0% Na_2O, and the ratio of Na_2O to SiO_2 is 1:2.84. These viscosity curves were obtained by measuring the time required for 250 cubic centimeters of slip to flow from an open-top Mariotte tube at a temperature of 83°F. The specific gravity of 1.83 was chosen because a higher specific gravity was not possible with the sodium silicates, even though obtainable with sodium tannate or sodium gallate. At this specific gravity, slips dispersed with sodium carbonate did not flow at all.

The preparation of sodium tannate and sodium gallate as described by Schramm and Hall[47] is as follows:

For sodium tannate, dissolve 30 grams of tannic acid in 100 cubic centimeters of hot concentrated sal-soda solution containing 58 grams of the salt in 100 cubic centimeters of solution; for sodium gallate, dissolve 12.5 grams of gallic acid in 100 cubic centimeters of sal-soda solution of the concentration described above.

Sodium tannate and sodium gallate appeared to be equally effective, and since sodium gallate is cheaper, this was used in many large-size trials averaging 1000 pounds of dry body and extending over a period of approximately nine months. It was found that the viscosity could be better controlled and the casting somewhat slowed down if 0.1% of tannic acid were added to the prepared slip. The tendency to jell, which was slight, could be easily and practically overcome by constant slow agitation. A slight skin on the top of the slip when poured into a mold was noted if the atmosphere was low in relative humidity.

All pieces shown in Fig. 1, as well as more complicated shapes made in multiple-piece molds as shown in Fig. 3, were easily cast in extremely

FIG. 3.

thin sections or of average hotel china weights. It was noted that these bodies cast as well as the average hotel china body and slightly better than semivitreous. Quite complicated pieces with deep engravings as well as articles with a high foot and cast-on handles were made. It appears that a slip of this type, properly prepared and controlled, should give no difficulty in production.

An interesting fact brought out in the investigation was that pinholes in the body, due to entrapped air in the slip, were practically nonexistent unless very hard molds were used or the specific gravity of the slip were low and the slip not sufficiently agitated. Observations made by Schramm and Hall[47] that sodium tannate and sodium gallate would be easier on molds were confirmed by these experiments. After about twenty-four hours' agitation, the slip remained at constant viscosity, provided, of course, that the specific gravity and temperature were kept adjusted to a definite point. It was noted that viscosity and specific gravity appeared to be at all times a direct and accurate check on the time and quality of the casting.

One objectionable point was noted in all cases where sodium salts were used in the dispersing agents. This was the concentration of the soluble sodium salts on the surface of the piece, especially on corners and other high points, owing to the quite rapid drying of this type of body. When fired in a reducing atmosphere where carbon monoxide is introduced while the bodies are still porous, the points where the soda has concentrated evidently fuse at a lower temperature, thus entrapping carbon from the carbon monoxide gas and causing a dark spot or line. This discoloration may vary from a grayish black to a rather light brown. Reducing the soda equivalent to 0.06% Na_2O still gave spasmodic trouble with the so-called soda markings in quantities enough to be considered quite serious. These markings would show plainly on edges or high points of the piece or on draining marks on the inside of hollow ware, such as cream jugs. In the finishing of the piece, by careful sponging with fresh water or slightly acidulating the water with acetic acid, the majority of the soda markings could be removed, although the extra cost and care necessary for this operation would raise the cost of the cast ware beyond the prescribed limits. It was therefore decided that for safe operation a completely organic deflocculant should be used, provided, of course that firing in a reducing atmosphere were decided upon. It was noted in all cases that the pieces fired in an oxidizing atmosphere would never show these soda markings, even when no finishing was done.

The use of ammonia replacing soda suggested itself, and trials were accordingly made using a combination of ammonium hydroxide and tannic acid in proportions varying from 0.05% NH_3 and 0.4% tannic acid to 0.2% NH_3 and 0.4% tannic acid. The best combination appeared to be 0.16% NH_3 and 0.25% tannic acid and was fairly satisfactory. With combinations of ammonia and tannic acid, it was possible to make quite fluid slips of specific gravities about 1.83, but all jelled soon after blunging stopped and did not drain clearly. It also appeared to have a detrimental effect on the plasticity. This jelling could be greatly retarded by the addition of 0.05% lignite.

At the time of writing this paper, not enough experimental data have been collected to draw any definite conclusions, although the trials show definite promise and cast almost as well as with sodium tannate or sodium gallate.

Very good results were obtained by the use of an organic dispersing agent prepared commercially by a chemical company and marketed under the name of clay deflocculant No. 2. This deflocculant evidently has an ammonia base as indicated by its appearance and odor. It is possible to obtain maximum gravities of about 1.85 with a resultant viscosity, after twenty-four hours' agitation, of 45 seconds for 250 cubic centimeters to flow from an open-top Mariotte tube at a temperature of 83°F. In many ways this deflocculant is quite remarkable. The ware releases quickly from the molds and the resultant cast is very plastic, facilitating trimming and the sticking on of handles or spouts. A typical viscosity curve with this dispersing agent is shown in Fig. 4.

Firing trials of ware made with ammonium tannate or clay deflocculant No. 2 showed that the soda markings previously noted with dispersing agents containing soda were entirely lacking. Further observations made upon the fired pieces cast by this method indicated a decided increase in the quality of color and translucency from which it might be concluded that

the dark soda markings previously noted on the corners and high points were the extreme condition and that a barely noticeable dark gray to brownish film had evidently formed over the entire surface.

The use of organic dispersing agents indicates that it will be interesting to investigate thoroughly the field of combinations of tannic, oxalic, citric, and gallic acids as was done by Dager.[48]

III. Conclusions

(1) Since, by the use of proper dispersing agents, bodies containing North Carolina and Florida kaolins are apparently cast successfully, the use of higher amounts of Florida kaolin to replace ball clay which is objectionable to color and translucency and is rather difficult to fire, etc., is hereby suggested. Inasmuch as Florida kaolin has a very high dry strength and the dispersing agents used also apparently greatly increase this property, it is believed possible to make large-size solid castings of sufficient dry strength without the additions of ball clay. The manufacture of large-size sanitary ware and electrical porcelain containing no ball clay becomes apparently practical, as fluid slips of high specific gravity can be made. Advantages of the elimination of ball clay, aside from improvements in color and translucency, are thought to exist, although these must be more definitely proved.

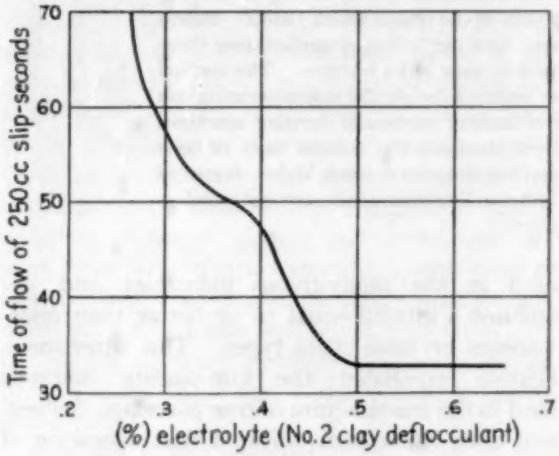

FIG. 4.

(2) In all experiments using sodium tannate, sodium gallate, or the organic deflocculant type, it was noted that specific gravity and viscosity are accurate measurements of the properties of the casting slip. It is believed that if this fact is true, it should be of distinct advantage, especially in industries using the casting procedure almost exclusively.

(3) Attempts to make successful casting slip with the commonly used dispersing agents of sodium carbonate and sodium silicate in bodies made up chiefly of North Carolina and Florida kaolin met with failure in every instance.

(4) Varying conditions as to the preparation of the body, temperature of the slip, hardness of the mold, etc., with the above electrolytes did not materially improve the casting behavior.

(5) The addition of fine-grained clays, when used in conjunction with sodium silicate and sodium carbonate, apparently improved the casting behavior.

(6) The use of organic colloids in the form of agar-agar, different flours, glycerine, etc., was not successful.

(7) Fine grinding of the North Carolina kaolins improved the working properties of the casting slip dispersed with sodium silicate or sodium carbonate without materially affecting any of the final properties except a slight increase in shrinkage.

(8) The use of sodium tannate or sodium gallate in conjunction with small amounts of tannic acid was found to be entirely successful and practical for casting the all-kaolin type bodies.

(9) The use of the above deflocculant materials increases dry strength and permits the casting of all-kaolin bodies which, if dispersed by ordinary electrolytes, would be too fragile for practical handling.

(10) It is believed that the use of sodium tannate and sodium gallate will materially increase the life of the molds.

(11) While the use of sodium tannate or sodium gallate is apparently successful in producing good quality casting slips, the soda contained, even when the amount is low, is enough sometimes to cause serious difficulty when firing bodies under reducing conditions.

(12) The use of organic dispersing agents appears practical, although exhaustive experiments have not yet been finished.

(13) Because all of the above experiments were carried on using laboratory or pilot-plant refined kaolin or the very first run of a commercial operation, exact measurements of some of the physical properties are not given, as these may vary from a standard product after this is produced.

(14) If in this case kaolin, generally considered as bad casting clay, was made to work apparently quite successfully, the reason for failure of other American clays to cast may lie in the choice of electrolytes. It is possible that each clay presents an individual problem.

PART VI, PLASTIC FORMING OF VITREOUS BODIES OF TRUE PORCELAIN OR CHINA TYPE, USING AMERICAN KAOLINS AS PLASTIC CONSTITUENTS, WITH NOTES ON A NEW METHOD OF MANUFACTURING STRAIGHT FLAT WARE

By R. E. Gould

Abstract

The plastic forming of bodies previously described in Parts IV and V was easily and simply done by the usual semivitreous methods on all articles except flat ware which could be jiggered but which deformed in the firing process. A new method is described in which the plates are held rigid during the bisque-firing process by braces made from the same body as the plates, supporting the points of the plates which tend to deform owing to the pull of gravity or internal stresses. One method of manufacturing these braces is described, which is apparently successful in most of its features. The method appears to be practical in that internal stresses induced during the manufacturing can be disregarded, thus making possible the use of simpler automatic forming machines and devices. Complete success has not yet been obtained, but failures have all been traceable to mechanical defects. Using this method requires a much higher degree of mechanical perfection than is common to the ceramic dinnerware industry but which is entirely within the bounds of practical possibility.

I. Introduction

With the bodies described in Parts IV and V of this investigation it was easy, even with moderately skilled labor, to form such articles as cups, dishes, bakers, bowls, etc. Any of the usual methods were found to be successful, and results of large-size trial batches indicated that these articles would give no trouble when made by the same methods as are commonly used in the semivitreous industries. All of the above articles gave no difficulties whatsoever in the firing, *i.e.*, the ware appeared to have even less tendency to warp or go crooked in the kiln than bodies in actual industrial production.

The forming of flat ware, however, while as easily done by jiggering or casting as the semivitreous or hotel-china type bodies, presented an entirely different and more difficult problem in bringing the ware straight from the kilns.

This difficulty could not be attributed to any bad characteristics of the body itself. There was less tendency to warp or twist than with the usual hotel-china type made with English clay or a true porcelain body made from European kaolins. The difficulties encountered were due to the specifications previously outlined in Part IV, which limited the forming to the methods used in the semivitreous industries and demanded a kiln-fill equal to or better than semivitreous or hotel china types. This latter specification precluded the kiln-placing methods used in the manufacture of true porcelain, Belleek, and bone china and indicated that a bracing of the ware somewhat similar to that used in hotel china would have to be employed.

As straight flat ware, which may be produced cheaply and from which a very good kiln-fill can be obtained, is an essential feature in any dinnerware manufacturing program, it was decided to study this phase intensively.

II. Procedure

Since the hotel china method of filling in between the plates with sand or other material apparently gives a good kiln-fill, trials were made using this procedure. It was decided to use the plain-edge six-inch and service plates for preliminary trials, as these represent the shapes with which the greatest difficulty in making a high percentage of straight ware is experienced in most plants.

The semivitreous method of batting out and jiggering was used, as this is the most satisfactory from a cost standpoint and probably causes quite

severe internal strains to be introduced into the piece, thereby giving any method of bracing a severe test.

Trials made by filling sand, calcined kaolin, and mixtures of calcined kaolin and alumina in between the plates, such as is done in the hotel china factories, did not give very good results. When fired under reducing conditions, sand is known to give trouble from iron specking, and this was found to be the case with carefully washed material. The same difficulty was experienced to a lesser degree with potter's flint, and here it was noted that the ware was actually forced out of shape, probably because of the greater tendency of the ground material to pack unevenly. Furthermore, the flint had a tendency to fuse into the surface of the pieces, and it was difficult to clean it off entirely. The ground quartz, furthermore, appeared to affect the translucency of the ware, making it distinctly greenish, although this might have been due to the firing schedules being not so adaptable to this type of stacking. Calcined kaolin alone or with mixtures of alumina appeared better than sand or the ground quartz, although in many trials it was noted that the ware when bunged over twelve high came crooked from the kiln, even though the pieces were straight when placed. It was also noted that the vibration had a tendency to break the thin ware, especially when the bungs contained more than a dozen pieces.

Although it was conceivable that lack of skill was responsible for the apparent failure of this method, it was decided to abandon it because of the following facts:

(1) At the temperature of cone 14 under reducing conditions and with the schedules used, all the materials considerably affected the translucency and had a tendency to pack and to fuse into the ware.

(2) Internal strains in the ware had a tendency to show up after the bisque fire in spite of the bracing.

(3) The method provided no way of bracing the bottoms so that they had a tendency to drop if the ware were thin.

(4) The ware apparently could not be bunged up over twelve high.

(5) The method did not appear to overcome strains which were introduced into the piece during the forming process.

(6) With the best materials of calcined clay and alumina, there was the bad feature of excessive dust and the fact that the materials after each fire would have to be reground or otherwise treated.

An analysis of all methods of forming flat ware and placing it in the kiln shows that they are basically similar, *i.e.*, the pieces are formed with the idea of minimizing or overcoming internal strains which show themselves during the firing process. In other words, the firing methods generally used do not exert much influence upon

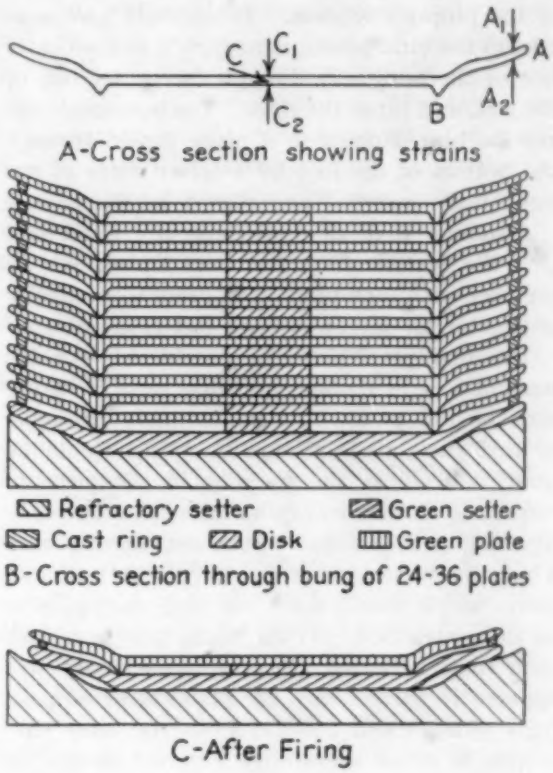

FIG. 1.

the ware other than to fix it into permanent shape and to bring out or magnify any internal strains which are incorporated into it during the forming. It appears that from this standpoint the manufacture of vitreous flat ware is diametrically opposite from glass, which is first melted and then molded into a fixed form. The fact that glass flat ware can be made straight when soft suggested the experiment of trying the same with ceramic ware.

Figure 1*A* is a cross-section of a typical flat plate, showing the points where internal stresses or the pull of gravity tend to force the piece out

of true. It appears that if the piece could be held rigid at A_1, A_2, C_1, and C_2 during the firing process, the tendency to fall owing to gravity when the piece is soft or to rise owing to internal strains could be overcome.

Since ceramic ware shrinks in the firing process, it is apparent that these braces should shrink with the piece to the same degree and at the same rate. This suggests the use of the same body for these bracings. Figure 1*B* shows a bung so braced in which the rims are held by rings of the proper height and the bottoms braced by disks of the proper thickness. This should give support to the vital points, namely, (1) at the center line of the bung, (2) through the center line of the feet, and (3) at the rims. The bottom should also be braced down to a plane passed through the bottom of the foot by a setter made of the same body material and placed in the center.

Assuming that all dimensions are exact and that the bottom disks and rings shrink exactly together with each piece, it appears theoretically impossible for pieces to come out crooked.

The first problem to be considered was the manufacture of the spacing rings separating the rims of the plates. Attempts made to jigger or cast these rings showed that this would be quite difficult as the fragility of the piece in respect to its size was quite extreme. The only jiggering method found was to cut the ring from a bat, thus wasting more than 95% of the work and body, which would make the ring as expensive as the plate itself. Trials made, however, with such rings indicated that the basic theory was apparently correct, *i.e.*, the plates came surprisingly straight and uniform from the kiln. Attempts to re-use these rings were not successful, as could be expected, because of their inability to shrink together with the entire bung. The sticking of one ring on one side was enough to throw all pieces above it out of true, but this experiment at least confirmed the theory that the pieces could be forced to a straight or crooked shape during the firing operation.

The obvious method of ring manufacture appeared to be overcasting the ring on the back of the plate itself. In this manner, the plate would shrink during the drying and firing process and brace the ring so that its manufacturing difficulties would be overcome. The flaw in this idea was the fact that an overcast ring of the same composition would be almost an integral part of the plate after the firing operation. It is a well-known fact that two dry pieces can be insulated from each other during the firing process by coating with a more refractory material which is neutral to the body. Alumina or mixtures of alumina and kaolin are generally successfully used for this purpose at a temperature of cone 14. Since this method was practical for separating two dried pieces after firing, it was thought that it should be equally good for parting plastic pieces after firing. Accordingly, trials were made first by coating the back of the freshly jiggered plate with finely ground alumina and overcasting the ring on this material. First trials showed immediate possibilities, and it was found that by adjusting the fineness of the

FIG. 2.

alumina and the thickness of the coat, the ring would remain firmly on the green and dry piece but separate easily after both were fired together. The successful mixture was made by grinding −150-mesh alumina wet in a ball mill for 72 hours. A grind of this length causes the alumina to stay in suspension fairly well when a slip is made up at a specific gravity of 1.80 and to spread easily on the plastic piece either with a brush or by a spray. Figure 2 shows a trial apparatus built for overcasting the rings. In this apparatus the slip is kept agitated at all times, and the plaster ring is filled by two hoses on opposite sides. Two overflows are provided midway between the center holes and slip is allowed to run through until the ring becomes solid, thus shutting off the flow. The viscosity and specific gravity of the slip appear to be very important, as too high viscosity will force the slip underneath the plaster ring and too low gravity will not cast a solid ring

FIG. 3.

successfully. It is also obvious that the slip must be of the fast-casting type; otherwise shrinkage in the plate before the removal of the plaster ring would cause the plate to crack inside of the ring. It was found that the body composition (as mentioned in Part IV) for slips dispersed with sodium tannate, sodium gallate, or organic clay deflocculant No. 2 was quite successful, provided the viscosity as measured by the flow of 250 cubic centimeters from an open-top Mariotte tube did not exceed 45 seconds. Inasmuch as a gravity as high as possible is desirable and the temperature materially affects the viscosity, the slip was kept at a temperature between 90° and 100°F. It was found that approximately ten minutes were required for casting the average ring solid and that a few minutes afterward the plaster ring mold was quite easily removed. Figure 3 shows the removal of the plaster ring mold from the overcast ring on a freshly jiggered plate.

It was decided to bung these plates as high as possible to obtain the maximum number of pieces per cubic foot of kiln space, and the point at which the bottom pieces would be seriously marked by the weight of the pieces above it was sought. At the time of writing this paper, the maximum number for the six-inch plates is found to be approximately 36 and for the service plates about 18. A bung of this size can obviously exert much weight on the bottom pieces, and it is noted that in placing the pieces on each other, the same points of contact must be observed as in the firing. Because internal strains in the piece can cause warpage in drying, it was necessary to bung the plates at the stage where they were still soft enough to bend to the predetermined shape. By so doing, the pieces were held rigid during the firing process and the only conceivable drawback would be the greater length of time necessary for drying the bung.

To insulate the feet, disks, and rings, a coat of alumina was applied to them as well as to the face of the plate itself. It was found that one coat of parting could give sticking difficulties if one minute point were not sufficiently covered, thus giving contact of body to body. Two coats were thus decided upon as an extra factor of safety. Figure 4 shows a bung of six-inch plates before and after firing; No. 1 is the green bung on a kiln slab with the rings showing in between the rims. The apparent difference in color is due to the coating of alumina on the ring not covering the ring in all places. Number 2 of this figure shows the fired bung with the rings (No. 4) and base setter (No. 3) removed. It should be noted also that the ring base (No. 3) is different from the setter shown in Figs. 1*B* and 1*C*. Either type is successful and that shown in Fig. 1 is perhaps more practical. It will be seen from this photograph that while the fired plates are not machine perfect, nevertheless the straightness could be considered at least average.

An apparently serious difficulty was encountered in the removal of the alumina from the finished plate. The fineness of grind necessary for the adherence of the ring to the green plate was such that to a certain extent the alumina fused or entered into the face of the plate. This surface could be sandblasted and enough of the alumina removed to make detection after glazing practically impossible. Trials, however, made with underglaze color showed that some colors, especially cobalt blues, were markedly intensified by the alumina still adhering to the face. Inasmuch as the color appeared to be slightly improved by the alumina, the possibility of coating the entire face suggested itself and was

FIG. 4.

tried but soon abandoned because of the greater difficulty in sandblasting evenly and cleanly. As the coat on the surface of the plate is used only as a parting and because the unground −150-mesh material when applied dry was found to be quite easily brushed off, trials were successfully made by dusting the top surface of the piece with the dry material, the majority of which could be shaken off after firing. The comparatively few grains sticking to the surface of the piece were easily and cleanly removed by a short period of sandblasting, and color trials showed that the presence of the alumina was at least enough to prevent any differences of the most sensitive coloring oxide.

III. Conclusions

At the time of writing this paper, it is impossible to state definitely whether or not this method is entirely practical because of the comparatively short time of experimentation. It appears, however, that a great many possibilities are opened up by using this or a similar method of procedure. It is further believed that intensive work will iron out the difficulties still encountered and that the method will eventually become entirely practical. It appears at this stage of the development that the following conclusions may be made:

(1) Flat ware may be made by any method permitting the removal of the finished piece from the mold. The difficulties in automatic forming of flat ware are thought to be the overcomplicated mechanisms for minimizing internal stresses and strains in the piece of ware.

(2) A greater number of pieces of thin flat ware can be fired by this method in a given cubic foot of kiln space than when using the placing methods common to true porcelain, bone china, Belleek, and perhaps hotel china and semivitreous ware.

(3) When firing, at least electrically, the use of saggers is unnecessary and other dead-weight refractories are reduced to a minimum.

(4) The body materials used in making rings and bases need not be wasted, as these can be reground and put back into the body as bisque pitcher.

(5) It was found that disks used for bracing the bottoms could be re-used an indefinite number of times.

(6) The difficulties so far encountered can be traced to imperfect mechanical set-ups, and it appears that in using this method the machines for making and placing the ware will have to work within prescribed size limitations. For example, varying the thickness of the plate rims a few thousandths of an inch will cause an accumulative error, making the plates progressively flatter or deeper from the bottom to the top. The setter and kiln slab must also be exactly level as any imperfection here will show in each succeeding piece. Fortunately, the working in size limits is much more practical and possible than delving into the unknowns of internal stresses set up during the manufacturing process. By this method the effect of internal strains is not shown, and their consideration is of little interest except from a highly theoretical standpoint.

(7) It is believed that the extra cost of placing the plaster ring mold on the freshly jiggered piece, the overcasting of the clay ring on the plate, and the removal of the plaster ring is not prohibitive, as these operations can be done continuously and at least semi-automatically, with a probable actual saving in labor costs over the present semivitreous method.

(8) By this method, minimum attention need be given to such factors as strengthening the various sections for bracing and the width or depth of the well or rims of the piece, and the pieces may be made of even and thin sections, which greatly facilitates the development of translucency.

(9) Large-size plates need not be made heavier than the smaller sizes, and the weights may be kept to the minimum necessary for service and translucency.

(10) The necessary sandblasting operation can be done quite economically and continuously as is being done in other industries.

(11) It is thought that the problems involved in making square plates, plates with escalloped edges, or pieces with embossed work on the face involve no serious or insurmountable difficulties.

(12) It is believed that a wider range in design of vitreous flat ware is opened up; for example, the possibilities of making very flat rims.

NOTE: The author wishes to give due credit for the possible success of this experiment to the valuable suggestions and practical advice and work of the laboratory assistants: E. W. Wilson, G. W. Fichter, and D. A. Deaderick.

PART VII, EXPERIMENTAL ELECTRICAL FIRING OF TRUE PORCELAIN AND CHINA-TYPE BODIES MADE FROM AMERICAN MATERIALS FOR THE DETERMINATION OF SUITABLE SCHEDULES

By R. E. Gould and A. J. Hedquist

Abstract

Hollow and flat ware of the average hotel china composition and maturing temperature and a modified hotel china or porcelain body maturing at cone 14 were fired at different rates under different atmospheric conditions. It was found that flat ware in bungs must be fired slower than the hollow ware, which was to be expected. Schedules for firing flat and hollow ware together are given. Some of the troubles which may be encountered through wrong schedules are noted. The effect of a reducing atmosphere introduced into the kiln while the ware was still porous was found to be a lengthening of the range between zero absorption and overfiring as well as an improvement in the white color of the fired piece.

I. Introduction

Experimental data covering the firing of hollow ware in an electrically heated kiln with a reducing atmosphere in the latter part of the firing have been previously discussed.[43] Here it was noted that fast schedules could be used on thin ware and that, when working with true porcelain where the high-temperature fire was the glost, the period from the beginning of the glaze fusion to the end of the firing must be slower than the preheating up to that point. The reason for this was traced to the fact that the glaze fused before the body became vitreous and that a too-fast schedule would entrap carbon monoxide in the body, which in turn would cause dark ware, blisters, or a brown-flecked glaze. It was also noted that leaving off the glaze permitted very fast firing with the latter part of the firing progressing as fast as the first parts. In a continuous electric kiln, where the cooling ware preheats the incoming ware, the heat transfer would naturally be much greater at higher temperatures, which fact appeared to be a strong argument in favor of the china-type firing over the true porcelain if the firing were to be done swiftly with an increasing rate of heat application.

This paper discussed also the use of a reducing atmosphere and its introduction at various temperatures.

Experimental data, as previously discussed, covered mainly comparatively thin ware and at that time no experimental work was carried on in the laboratory with heavier ware or thin ware placed in bungs which could conceivably be called heavy or difficult to heat.

The firing of bungs of plates as described in Part VI, as well as experimental work on hotel china-type bodies where the plates were braced with sand, potter's flint, or calcined china clay, presented a somewhat different problem, and it was apparent that the speed of heating could not be as great as with thin individual pieces.

II. Procedure

As previously mentioned in Part VI, the hotel china-type body maturing at cones 10 to 11 fired under reducing conditions became dark gray to black, even when fired in the form of hollow ware, if the heating was done at the rate of 250°C per hour. This difficulty was largely overcome if the heating was done more slowly with a maximum of 125°C per hour. The reason for the dark color was thought to be the entrapment of carbon from the carbon monoxide gas in the low-fusing body, and by reducing the extra fluxes so that the maturing temperature was cones 13 to 14, the sensitiveness of the bodies was overcome to a great extent. Hollow ware made from higher maturing bodies containing extra fluxes could be fired as rapidly as bodies maturing at the same temperature containing high feldspar and no extra fluxes, and the resulting ware appeared to be almost as good as the high feldspar type in every respect as to translucency and color. It appeared at this time that the greater ease and flexibility of firing to cones 13 or 14 and the greater translucency and better color which could be made more than compensated for the slight extra heat necessary to reach this temperature.

Up to this time, the final maturing was done by soaking for 30 to 40 minutes at a temperature of 1400°C. Slowing the schedule, lengthening the soak, and reducing the temperature to

1350°C appeared to be as good or slightly better for the ware than the higher temperatures and shorter soak. It was found that 1350°C with a one- or two-hour soak would bring cone 14 half way to touch.

At this time serious experiments were begun in firing the six-inch and service plates bunged up from 24 to 36 high, as mentioned in Part VI. Schedules of 100°C per hour with the introduction of a reducing atmosphere at 1000°C were first tried. Results showed that the ware was fired satisfactorily, although the plates at maturity did not have the same degree of clear translucency as the hollow ware. It was also noted that unless the plates were thoroughly dry, large, partly opened blisters would form, especially in the center of the bung. Experiments were then run by reducing the schedule in 10°C per hour increments, and it was found that a temperature rise per hour of 50°C, even with wet flat ware stacked 36 high, gave very good results. The improvement here was believed to be solely due to the lengthening of the time for drying, and experiments were then run increasing the schedule in 10°C per hour increments after 500°C had been reached. It was found that after 500°C a schedule of 70° to 80°C per hour could give spasmodic trouble due to entrapped carbon in the body. This carbon was first attributed to carbon from the reducing atmosphere, but introducing the gas at a higher temperature or reducing the percentage of CO did not seem to have any material effect. It appeared that even with no ball clay present in the body, the kaolin contained enough carbonaceous material to be the cause of this difficulty. Slowing the schedule to 60°C per hour after 500°C appeared to reduce this trouble. It was believed that at 800°C or 1000°C the majority of carbon from the body itself should be released, and trials were made by increasing the schedule from this point on in increments of 10°C per hour. Results indicated that the difficulty of visible carbon spots was not met with if the schedules beyond 800°C were increased 10°C per hour. The fastest satisfactory schedule then was 50°C per hour to 500°C, 60°C per hour from 500° to 800°C, and 70°C per hour from 800°C to the maturing temperature.

The firing schedules so far mentioned are shown graphically in Fig. 1. These firing schedules represent the maximum speeds at which the various ware could be fired with success in the electrically heated periodic kiln, and it was found in each case that slower schedules gave as good and perhaps better results. Curve I was the maximum where good results could be constantly obtained on bodies maturing at 1350° to 1400°C or cone 14 without the glaze. No apparent difference was noted if the body contained slight additions (1 to 2%) of additional fluxes such as dolomite or whiting or if it was

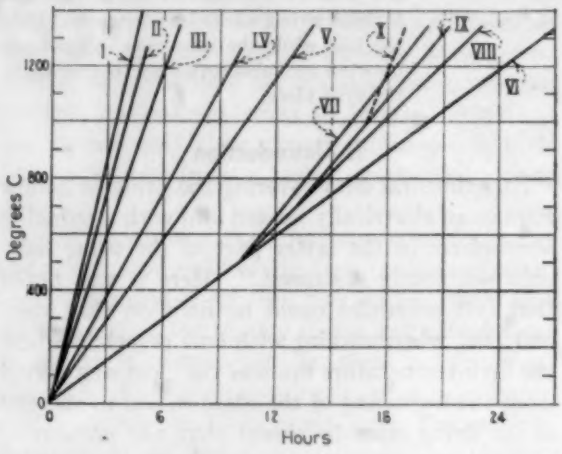

FIG. 1.—Preheating schedules. *Note:* Soaking periods not shown; regular hotel china maturing point, 1270°C; modified hotel china maturing point, 1350° to 1400°C.

Curves I to IV: Hollow ware only. (I) Good for hollow ware of modified hotel china or porcelain; (II) dark ware, regular hotel china, reducing atmosphere; (III) good for high fire porcelain or china (reducing); (IV) good for regular hotel china type, oxidizing or reducing.

Curves V to X: Hollow and flat ware. (V) Good for absolutely dry bungs of flat ware, bad blisters and dark if wet; (VI) good for wet flat ware, no blisters or carbon spots; (VII) no blisters, but carbon spots likely; (VIII) no blisters or carbon spots; (IX) no blisters or carbon spots; (X) probable future schedule increase after 1000°C.

of the high feldspar type. Curve II shows a slower schedule on which dark gray to brownish color was obtained even with thin, dry hollow ware of the regular hotel-china type maturing at cones 11 to 12. Curve IV represents the maximum at which this type of ware could be fired either under oxidizing or reducing conditions without bad results. Curve III represents a schedule at which the modified hotel china body, treated as a true porcelain and fired under reducing conditions, will come good, *i.e.*, with a cone 010 bisque and cone 14 glost with a hard glaze. Curve V shows the rate per hour at which absolutely dry bungs of flat ware may be fired. It was found that for this schedule the bungs

had to be dried at a temperature of 120° to 150°C for at least twenty-four hours which, of course, is quite impractical. If the ware had been dried for a considerable period (72 to 84 hours at 80°C), bad blistering and dark ware occurred in every instance. Curve VI represents a schedule at which all ware came good, *i.e.*, both flat and hollow ware put into the kiln wet, semidry, or completely dry. On this schedule, no blistering or carbon spots whatsoever occurred in the body. Curve VII represents an increase in the schedule shown in curve VI in which the blistering due to wet ware was absent but where carbon spots probably due to unburned carbonaceous matter in the body spasmodically appeared. Curve VIII represents an increase in the schedule shown in curve VI from 500°C but a marked slowing of the schedule shown in curve VII to eliminate the carbon spots. On this schedule no carbon was noted either in flat or hollow ware. Curve IX represents an increase in the schedule depicted by curve VIII after 800°C at which the carbon in the body should be burned out. This schedule was successful, as no blistering or carbon spots, even with wet ware, were noted. Curve X indicates the probable future increased schedule after 1000°C as it has been found that at this temperature heat transfer from the outside to the inside of bungs becomes more rapid, and it is believed that in a recuperative tunnel kiln the heating at this point will actually be much more rapid.

All of the above schedules were determined by heating up the kiln as evenly as possible. With four Globars over the ware and four underneath it, the heat distribution as determined by four or six thermocouples put into the kiln in different positions was in all cases very good, especially after 300° to 400°C. It was then thought interesting to maintain the same heating schedule, as determined by one thermocouple midway between the Globars in the back of the kiln, by applying the heat by a maximum of four of the eight Globars. This would naturally give quite uneven conditions and would be somewhat representative of conditions in a gas-fired kiln where the differential between the flame and the ware to be heated is quite great. It was interesting to note that on all schedules except that given by curve VI the ware was bad, showing frequent carbon spots and a poor color.

Gas could be introduced from 700° to 1100°C and held throughout the soak or cooling with equally good results. It was also noticed here that the percentage of carbon monoxide could vary from 5 to 30% without appreciable difference in the final quality of the ware, and it appeared that the presence of carbon monoxide was all that was required. Curiously, no difference was noted in the firing of the six-inch or service plates. It had been assumed that the service plates would have to be fired on a slower schedule than the six-inch plates, but it was noted in every case that where firing was done too fast, the same faults appeared on both sizes and in the same degree. This observation, however, must be thoroughly checked.

At this time, experiments were run to determine the length of soak necessary for obtaining the same degree of translucency in flat ware as in the hollow ware. The soaking period was increased in increments of 30 minutes, and it was found that five to six hours gave excellent results. At a temperature of 1350°C, however, thin hollow ware placed in the same kiln had a tendency to deform. This was finally corrected by reducing the temperature 5° (to 1345°C). This temperature thoroughly melted cone 13 and started cone 14. Several firings at this temperature, stopped at one and three hours soaking time, showed that cone 14 was not being appreciably melted down by the soaking period, *i.e.*, almost at the beginning of the soak the cone had started to deform and remained the same throughout the entire period.

At this time it was thought desirable to ascertain the temperature differential between the inside and outside of a 36-piece high bung of six-inch plates. This was done as shown in Fig. 2*A* by inserting one thermocouple through the top 18 pieces and placing the second thermocouple at the edge of the bung at the level of the one placed inside. The temperature as recorded by these couples is given in Fig. 2*B*. Results of this test were very interesting, especially those parts marked *A*, *B*, *C*, and *D*. Part *A* probably shows the evaporation of the mechanical water. It appeared that the temperature inside of the bung had been held low due to the evaporation of the water up to this point. Part *B* seems to indicate the driving off of the chemically combined water where the temperature differential between the inside and outside was increased by the evaporation of this water. Part *C* shows the tem-

perature differential to be rapidly decreasing, and it is thought that the difference is due to the heat being radiated from all sides of the kiln. It had previously been observed in working with electrically heated kilns that the heat distribution from 1000°C on became very good regardless of the setting of the kiln. Part *D* shows that, at the maturing temperature, the inside and outside very quickly come to equilibrium so that the heat work done during the soak is approximately

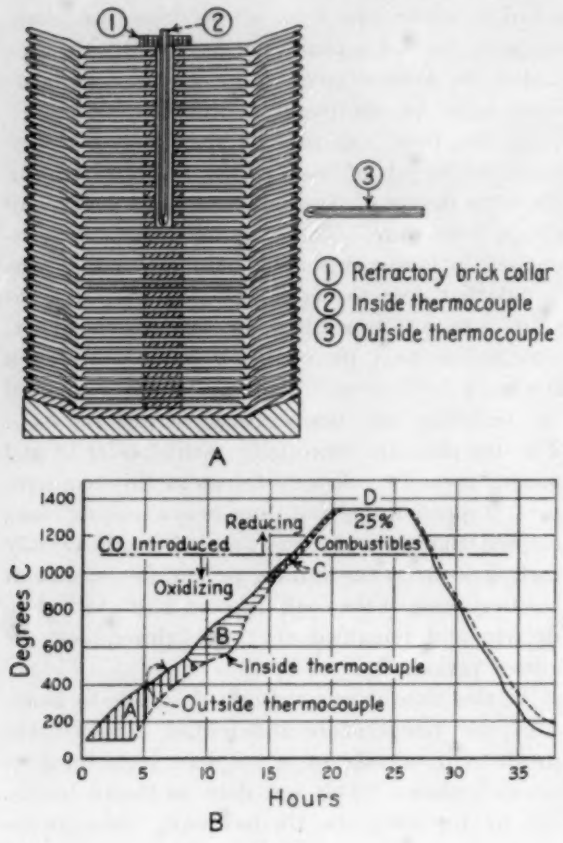

FIG. 2.

equal on the inside and outside of the piece and that the greater translucency noted with longer soaking was probably due to thermochemical reactions taking place within the body itself.

Up to this time all work in the laboratory had been concentrated on the production of pure white bodies by the use of good materials fired under reducing conditions. Experiments with hotel china fired under oxidizing conditions and masking the yellowish color with a blue stain had indicated that the production of a good white was far easier and better than the use of reducing atmospheres. The production of ivory, however, presented an entirely different problem, and it was believed that firing the ware in an oxidizing atmosphere would produce a light ivory color. This would be the easiest approach and the most satisfactory from every standpoint. Trials were accordingly made of flat and hollow ware using the schedules and maturing temperatures last noted. It was observed that the color of the pieces was, as expected, a light pleasing ivory and that the translucency was good but that all pieces, both flat and hollow ware, were covered with blisters of the type generally classified as overfiring, although the temperature as indicated by cone and pyrometer was exactly the same as that where good results were obtained under reducing conditions. Many careful checks were run using the same body, schedule, maturing temperature, and soaking period as came good under reducing conditions, and in all cases the results showed the same tendency to overfire when oxidizing conditions were maintained. It appeared from these results that the firing range of the body as determined by the overfiring is materially lengthened by the presence of carbon monoxide in the kiln atmosphere.

At this point a rather fortunate accident occurred in the failure of a recording potentiometer on a kiln being fired under reducing conditions. This pyrometer began registering several hundred degrees low some time after 1000°C had been reached, and before the trouble was located, the maturing temperature far exceeded the 1345°C limit. Examination of cone 14 placed in this kiln indicated that a probable temperature of about cone 20 had been reached, as cone 14 had completely melted to a glaze. The ware in this kiln had, of course, deformed very badly, and the plates in the flat-ware bung had almost completely fused together. The alumina dusted on the plates was hardly distinguishable, showing that this had been almost completely absorbed by the body. The ware, however, was *not* overfired and was completely free from blisters, although this same body was badly overfired and blistered at a temperature of 1345°C, cone 14 start, under oxidizing conditions.

Inasmuch as the bodies used in these tests contained 2% dolomite, it was thought possible that the overfiring in an oxidizing atmosphere might be due to the dolomite reacting with the feldspar, quartz, or kaolin. Accordingly, more

trials were made firing bodies with high feldspar and no dolomite, set together with the dolomite-containing bodies. No difference in behavior was noted, the high feldspar bodies blistering as badly as those containing the extra fluxes.

It was then thought that perhaps the final maturing in a reducing atmosphere might in some way overcome the tendency of bodies to blister, and several firings were made using the same previously mentioned schedules but introducing the reducing atmosphere at points determined by trial where complete vitrification had been reached. It was noted from these tests that the finishing heating and soaking of ware in a reducing atmosphere caused the ware to overfire as badly as that done by completely oxidizing, indicating that the action of the carbon monoxide to prevent blistering must take place while the ware is still somewhat porous.

An interesting fact noted in the determination of the point where complete vitrification is reached was that it was possible to obtain on the same piece both an ivory and white color in which the ivory would blister or overfire and the white would remain good. Assuming that the introduction of the reducing gas has no effect on a completely vitrified body, the determination of the complete vitrification point by the introduction of gas is hereby suggested. This point appears to be quite sharp and takes place within 1° or 2°C.

It is believed by the writers that the facts noted above in regard to the firing behavior of ceramic bodies in an oxidizing or reducing atmosphere can be of great interest, inasmuch as it appears possible to carry on thermochemical reactions by means of temperatures and soaking periods not conceivably possible under completely oxidizing conditions. It also appears possible to have at least a factor of safety in vitrification in those types of ceramic ware where porosity, even in tiny amounts, is a distinct drawback, such as hotel china, high-tension porcelain, and sanitary ware, and where under present firing practice it is difficult to be assured at all times of complete vitrification because of the danger of overfiring.

Inasmuch as the firing tests so far had all been carried on with the special types of bodies, it was decided to observe the visible effect of firing high- and low-tension plastic process and dust-pressed electrical porcelain bodies in reducing and oxidizing atmospheres. Materials for these tests were furnished by an electrical porcelain plant which may be considered average and in which the firing is done continuously in an oil-fired tunnel kiln of modern design. Pieces tested consisted of (1) plastic process strain insulators, (2) plastic process tubes, both small and large, (3) small plastic process pin-type insulators, and (4) various dry-pressed electrical porcelain fittings, such as knobs, sockets, switch parts, etc.

Firing under plant conditions is done to cone 11 down under oxidizing conditions in about twenty-seven hours. The first trial was made following the same schedule to the same cone position as in the factory. Results obtained by observing the glaze and the fracture and by testing the vitrification by applying ink or dye indicated that the pieces fired electrically under oxidizing conditions were nearly the same as those fired in the oil-fired tunnel kiln. The next firing was made to cone 13 down under reducing conditions with a regular bisque firing, per schedule No. IX (Fig. 1, p. 208), except that the reducing gases were introduced at 1000°C, which is earlier than necessary for the regular bodies treated in this study, but it was thought that the introduction into the bodies containing high ball clay at 1000°C would first show whether or not the oxidation of the carbonaceous matter was complete and, second, permit the gases to penetrate the body before the glaze had fused. Observations on the electrical porcelain from this test indicated that while the structure of the pieces was considerably more glassy, there were no visible signs of overfiring having taken place either in the dry-pressed or plastic-processed pieces. Furthermore, no signs of black coring were noted, and as was to be expected, the color of the porcelain as shown by fracture was greatly improved, being a good white for this type of ware.

The next firing was made following the same temperature and schedule but holding the atmosphere oxidizing throughout the entire period. It was noted that the dry-pressed ware from this fire, as well as tubes which probably contain a higher percentage of ball clay than the regular high-tension body, showed decided overfiring, being covered on the surface with small blebs and pimples and showing quite large blebs and openings in the fracture. The high-tension body was distinctly overfired but did not contain as

many blebs as the dry-pressed and tube bodies. It appeared that overfiring of these bodies had definitely started between cones 11 and 13 down, probably near cone 12 half-way down to touch.

To determine the point at which definite visible overfiring would take place under reducing conditions, the temperature was raised in the next trial to cone 15 down. The ware from this fire showed no visible signs of overfiring, being entirely free from blebs, although the fracture showed that all pieces were very glassy. It was interesting to note that at this temperature the fracture of the dry-pressed pieces changed from the typical rough stony type common to dry-pressed ware to the conchoidal type generally indicative of the plastic process.

Inasmuch as cone 15 down gave no indications of overfiring, one more trial was made in which the temperature was raised 40°C, bringing cone 17 almost to touch. Examination of this ware showed merely an advancement of vitrification as noted at cone 15 down. All pieces were very glassy but still free from the typical bleb structure of overfiring. The soaking period was six hours at the maximum temperature as had been done before, and it was expected that at least some pieces would show definite signs of slumping due to softening. This was not noted, however, all pieces being apparently as free from warpage as those fired at the lower temperatures. The glazes, which consisted of the typical brown, transparent white, and average blue, all flowed from the pieces, and the colored glazes faded out as could be expected. It was also noted that the glaze on the dry-pressed ware crazed badly.

To see if the overfiring under oxidizing conditions would be materially increased with higher temperatures, a firing was made to cone 15 down under oxidizing conditions. In this firing all pieces swelled, and the fractures showed them to be extremely porous. At this temperature even the heavy pieces such as the strain insulators gave definite indications of softening, tending to bulge at the bottoms. Pieces of regular bisque ware fired with the above tests behaved the same as electrical porcelain in all cases except at the first firing of cone 11 down under oxidizing conditions in which the regular ware was still somewhat porous.

III. Conclusions

The results of these tests give the following indications:

(1) The firing of the particular types of ware studied in this investigation appears to be successfully done by electrical heating under reducing conditions.

(2) Observations as to temperatures of introduction of reducing atmospheres[43] appear to be borne out.

(3) Bungs of flat ware can be fired as successfully as hollow ware, and it is believed that the trials noted indicate the complete feasibility of electric firing, even of very thick sections, provided that the proper schedule is maintained.

(4) Wet ware fired on too fast a schedule can cause blistering.

(5) Black spots or dark ware due to carbon may be produced by (*a*) having the maturing temperature of the body too low and using too fast a schedule in which case the dark color probably comes from the carbon monoxide gas; (*b*) entrapping the carbon from the carbonaceous material from the body by a too-fast schedule or the introduction of a reducing atmosphere at too early a point; and (*c*) uneven heating in the kiln during the preheating periods.

(6) The translucency of bunged-up flat ware appears better by soaking four or five hours at a lower temperature than by holding for a shorter period at a higher temperature.

(7) The temperature differential between the inside and outside of a bung appears to be greatest at those points (*a*) where the mechanical water is being evaporated and (*b*) where the chemically combined water is being evaporated.

(8) At a schedule of 70°C per hour, the rate of heat transfer from 1000°C to the finishing temperature from the outside to the inside of a bung is quite rapid, and a period of 20 to 30 minutes is required to bring the temperature to the same point after the soaking period is reached.

(9) The reducing atmosphere for producing a white color apparently need be introduced only a few degrees before vitrification of the body takes place.

(10) Carbon monoxide introduced into the kiln atmosphere after vitrification has taken place has no noticeable effect upon the color of the body.

(11) A reducing atmosphere introduced into the kiln during the firing process before the body

is vitrified appears to lengthen greatly the firing range of the body. This range is thought to be at least six or eight cones, and the effect appears to be the same on bodies containing only feldspar as a flux as on bodies containing extra fluxes such as dolomite.

(12) It is believed that the possible lengthening of the firing range of a ceramic body by the introduction of a reducing atmosphere into the kiln before the body becomes vitrified can permit a greater approach to equilibrium within a body owing to increased temperature and lengthening of the soak.

(13) A test for the point of complete vitrification is suggested by the introduction of carbon monoxide at that point where the carbon monoxide no longer has an effect on color and translucency or where both reducing and oxidizing conditions are noted on the same piece.

(14) The short study of vitrification ranges on typical dry-pressed and plastic-processed electrical porcelain indicates that the firing range, at least as determined by the bleb structure visible to the naked eye, can be greatly increased. Since the maximum temperature obtainable with safety in the electric kilns at hand was cone 17 down, the point where definite softening or bleb structure began could not be determined. It was noted, however, that this body was mature at cone 11 down under oxidizing conditions and began to overfire at about cone 12 down, but under reducing conditions it showed no overfiring up to cone 17 down. More exact measurements on volume change, density, etc., used in methods described by Riddle and McDanel,[3] and microstructure, as well as changes in physical characteristics, such as strength, resistance to thermal shocks, and increase or decrease of dielectric strength, etc., will be studied and the data presented in a later paper.

BIBLIOGRAPHY

(1) T. A. Klinefelter and W. W. Meyer, "Properties of Some American Kaolins and Comparison with English China Clays," *Jour. Amer. Ceram. Soc.*, **18** [6] 163–69 (1935).

(2) A. S. Watts, "Comparison of American China Clays as Porcelain Ingredients," *ibid.*, **2** [2] 151–55 (1919).

(3) F. H. Riddle and W. W. McDanel, "Some Types of Porcelain," *ibid.*, **1** [9] 606–27 (1918).

(4) S. E. Hemsteger and W. C. Stief, "Use of Georgia and North Carolina Kaolins in Semiporcelain Body," *ibid.*, **9** [7] 444–45 (1926).

(5) Andrew Foltz, "Development of a Casting Body for Vitrified Sanitary Ware from American Materials," *ibid.*, **8** [6] 383–90 (1925).

(6) A. V. Bleininger and W. W. McDanel, "Use of American Raw Materials in Manufacture of Whiteware Pottery," *Jour. Amer. Ceram. Soc.*, **3** [2] 134–48 (1920).

(7) E. H. Fritz, "American Clays as Compared to English Clays in Whiteware Bodies," *ibid.*, **8** [4] 253–56 (1925).

(8) R. Rieke and W. Faust, "Sources of Yellow Discoloration on Porcelain" (Die Ursachen gelber Verfarbungen von Porzellan), *Ber. deut. keram. Ges.*, **10** [12] 567–76 (1929); *Ceram. Abs.*, **9** [4] 291 (1930).

(9) A. S. Watts, "Mining and Treatment of Feldspar and Kaolin in the Southern Appalachian Region," *U. S. Bur. Mines Bull.*, No. 53, 170 pp. (1913).

(10) W. S. Bayley, "Kaolins of North Carolina," *N. C. Geol. and Econ. Survey Bull.*, No. 29 (1925).

(11) Hewitt Wilson, A. L. Bennett, and F. T. Heath, "Preliminary Report on Residual Kaolin and Feldspar in the Pacific Northwest," *Jour. Amer. Ceram. Soc.*, **6** [3] 475–90 (1923).

(12) H. G. Schurecht, "Mechanical Movement of Water through Certain Clays and Its Control," *ibid.*, **5** [12] 928–36 (1922).

(13) C. F. Binns, "Comparison of Some Kaolins in Respect of Size of Grain," *Trans. Amer. Ceram. Soc.*, **17**, 356–71 (1915).

(14) Jerome Alexander, "Ultramicroscopic Examination of Some Clays," *Jour. Amer. Ceram. Soc.*, **3** [8] 612–25 (1920).

(15) H. G. Schurecht, "Elutriation Tests on American Kaolins," *ibid.*, **3** [5] 355–78 (1920).

(16) H. G. Schurecht, "Sedimentation as a Means of Classifying Extremely Fine Clay Particles," *ibid.*, **4** [10] 812–21 (1921).

(17) W. G. France, "Ultramicroscopic Motion Picture Study of the Relation of Colloidal Content and Plasticity in Clays," *ibid.*, **9** [2] 67–76 (1926).

(17a) H. J. Bryson (N. C. State Geologist), *N. C. Dept. of Conservation and Development, Econ. Paper*, No. 64, (1937).

(18) "Tentative Method for Sampling Clay Deposits," *Jour. Amer. Ceram. Soc.*, **11** [6] 443–44 (1928).

(19) A. V. Bleininger, "Note on the Electrical Separation of Clay," *Trans. Amer. Ceram. Soc.*, **15**, 338–44 (1913).

(20) G. A. Bole, "Mechanism of Plasticity from Colloid Standpoint," *Jour. Amer. Ceram. Soc.*, **5** [8] 469–77 (1922).

(21) H. E. Ashley, "Colloid Matter of Clay and Its Measurement," *Trans. Amer. Ceram. Soc.*, **11**, 530–95 (1909).

(22) A. V. Bleininger and C. E. Fulton, "Effect of Acids and Alkalies upon Clay in the Plastic State," *ibid.*, **14**, 827–39 (1912).

(23) F. F. Grout and Frederick Poppe, "Plasticity of Clay," *ibid.*, **14**, 71–81 (1912).

(24) R. E. Wilson and F. P. Hall, "Measurement of Plasticity of Clay Slips," *Jour. Amer. Ceram. Soc.*, **5** [12] 916–27 (1922).

(25) C. W. Parmelee and H. W. Moore, "Some Notes on Mechanical Analysis of Clays," *Trans. Amer. Ceram. Soc.*, **11**, 467–93 (1909).

(26) I. E. Sproat, "Kaolin Refining," *ibid.*, **18**, 767–811 (1916).

(27) A. V. Bleininger and C. S. Kinnison, "Electrical Conductivity of Clays and Clay Suspensions," *ibid.*, **15**, 523–31 (1913).

(28) H. G. Schurecht, "Relation of Salt to Clay in Purification of Clays," *ibid.*, **19**, 460–78 (1917).

(29) H. G. Schurecht, "Notes on Use of Sulphuric Acid in Sedimentation of Kaolins," *ibid.*, **19**, 130–45 (1917).

(30) G. H. Brown and W. L. Howat, "Use of Deflocculating Agents in Washing Clays and Effect of Process upon Color," *ibid.*, **17**, 81–90 (1915).

(31) F. P. Hall, "Effect of Hydrogen-Ion Concentration upon Clay Suspension," *Jour. Amer. Ceram. Soc.*, **6** [9] 989–99 (1923).

(32) R. F. Geller and D. R. Caldwell, "Absorption of Sodium Hydroxide by Kaolins," *ibid.*, **4** [5] 468–73 (1921).

(33) Norvil Beeman, "Effect of Hydrogen-Ion

Concentration upon Sedimentation of Clay," *Jour. Amer. Ceram. Soc.*, **14** [1] 72–87 (1931).

(34) C. E. Curtis, "Electrical Dewatering of Clay Suspensions," *ibid.*, **14** [3] 219–63 (1931).

(35) S. J. McDowell, "Effect of Various Sodium Silicates and Other Electrolytes on Clay Slips," *ibid.*, **10** [4] 225–37 (1927).

(36) W. A. Taylor, "Hydrogen-Ion Control in Ceramics," *ibid.*, **10** [4] 243–58 (1927).

(37) D. W. Randolph and A. L. Donnenwirth, "Hydrogen-Ion Measurements on Clay Slips," *ibid.*, **9** [8] 541–47 (1926).

(38) A. H. Fessler and H. M. Kraner, "Hydrogen-Ion Concentration and Electrical Conductivity of Clay Slips," *ibid.*, **10** [7] 501–507 (1927).

(39) E. W. Scripture, Jr. and Edward Schramm, "Deflocculation of Clay Slips and Related Properties," *ibid.*, **9** [4] 175–84 (1926).

(40) A. H. Fessler and H. M. Kraner, "Hydrogen-Ion Concentration and Electrical Conductivity of Clay Slips: Part II, Laboratory Study," *ibid.*, **10** [8] 592–97 (1927).

(41) G. J. Bouyoucos, "Hydrometer Method for Making Mechanical Analyses of Soils," *Bull. Amer. Ceram. Soc.*, **14** [8] 259–62 (1935).

(42) A. S. Watts, "Selection of Dinnerware for the Home," *O. S. U. Eng. Expt. Sta. Circular*, No. 21, 14 pp. (1930); *Ceram. Abs.*, **10** [3] 205 (1931).

(43) R. E. Gould and M. G. Toole, "Preliminary Experiments for Development of Continuous Electric Kiln for High-Temperature Burning," *Electrochem. Soc. Preprint*, No. 70–11, pp. 123–37 (Oct., 1936).

(44) H. Bollenbach and E. Kieffer, Laboratory Manual for the Clay Industry (Laboratoriumsbuch für die Tonindustrie). Published by Wilhelm Knapp, Halle (Saale), 1929. 2d ed. with 55 illustrations; *Brit. Clayworker*, **37** [439] 317 (1928); *Ceram. Abs.*, **8** [2] 150–51 (1929).

(45) F. P. Hall, "Casting of Clay Ware—A Résumé," *Jour. Amer. Ceram. Soc.*, **13** [10] 751–66 (1930).

(46) H. W. Webb, "Alkaline Casting Slip: Part I," *Trans. Ceram. Soc.* [*Eng.*], **33**, 129–67 (1933–34).

(47) Edward Schramm and F. P. Hall, "Notes on Casting Slip," *Jour. Amer. Ceram. Soc.*, **17** [9] 262–67 (1934).

(48) P. W. Dager, "Notes on High Specific Gravity Slips," *ibid.*, **18** [7] 201–203 (1935).

ON THE CRYSTAL STRUCTURE OF SODIUM METABORATE, $NaBO_2$*

By Ssü-Mien Fang

According to the results of an article on the properties of sodium metaborate by Cole, Scholes, and Amberg,[1] $Na_2O{\cdot}B_2O_3$ is hexagonal with a unit cell, $a = 6.85$Å, $c = 10.95$Å, and with 16 molecules to the cell. The observed density is reported to be 2.343, and this value is said to be exactly the same as obtained from the lattice constants.

We have prepared single crystals of $NaBO_2$ and have begun a complete crystal-structure determination using the oscillation and Laue methods. Our results are entirely different from those reported by Cole, Scholes, and Amberg. We determined the density by the suspension method to be 2.464 ± 0.005. For the dimensions of the hexagonal cell, we find $a = 11.93 \pm 0.03$Å, $c = 6.46 \pm 0.02$Å. This gives 18 (18.07) molecules of $NaBO_2$ in the cell. The true unit cell, however, proves to be rhombohedral with $a = 7.22 \pm 0.02$Å, $\alpha = 111°30'$ and contains six molecules. The space group is D_{3d}^6.

Accordingly, the interpretation of the X-ray data given in the article by Cole, Scholes, and Amberg is wrong, and their density determination inaccurate.

Their reported cell dimensions and number of molecules per cell (16 molecules $Na_2O{\cdot}B_2O_3$) would correspond to a density of 7.81.

The results of the complete structure determination will be published in the *Zeitschrift für Kristallographie*.

* Received February 3, 1937.

[1] S. S. Cole, S. R. Scholes, and C. R. Amberg, "System R_2O–B_2O_3: II, Properties of Anhydrous and Hydrated Metaborates of Sodium and Potassium," *Jour. Amer. Ceram. Soc.*, **18** [2] 58–61 (1935).

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CORRECTION IN SPECIFIC GRAVITY AND UNIT CELL SIZE OF $Na_2O \cdot B_2O_3$*

By S. S. Cole, S. R. Scholes, and C. R. Amberg

Recalculation of the unit cell size of $Na_2O \cdot B_2O_3$ and the specific gravity data reported by us[1] indicated that an error existed in the original calculation. Since the reported unit cell size was in agreement with the observed specific gravity, it appeared that an error also existed in this observed value. Therefore, a new set of samples of sodium metaborate, $Na_2O \cdot B_2O_3$, were prepared and the specific gravities determined, because it appeared probable that the original sample had become hydrated in the course of making the specific gravity determination.

The original X-ray data were then recalculated to obtain a unit cell size in agreement with the new observed specific gravity value. The results of these calculations and observations are given in the accompanying table.

The specific gravity was obtained by means of a pycnometer with kerosene as the liquid. The kerosene had been previously dried over metallic sodium. The finely powdered samples, weighing 10 grams, were evacuated in the pycnometer under the kerosene for one hour at 1.0-millimeter Hg pressure to insure the removal of occluded air. The specific gravity was found to be 2.462 ± 0.002. The previously reported specific gravity was given as 2.343. It is evident, therefore, that the original samples had become hydrated by the tetralene which was used in the previous specific gravity determinations.

The size of the unit cell was recalculated from the original X-ray data and found to be $a_0 = 11.90$, $c_0 = 6.54$, and $c/a = 0.55$. The specific gravity calculated from these values is 2.434, assuming 9 molecules in the unit cell. This is in good agreement with the observed specific gravity.

X-Ray Data on Sodium Metaborate*

$\sin^2\theta$	hkl	$4/3(h^2+k^2+hk)+\left(\frac{al}{c}\right)^2 = S$	$\sin^2\theta \div S$
0.0170	110	4.0	0.00425
.0226	200	5.33	.00424
.0369	201	8.64	.00426
.0558	002	13.22	.00422
.0632	301	15.31	.00413
.0662	220	16.0	.00414
.0724	112	17.22	.00420
.0802	221	19.31	.00415
.0879	400	21.3	.00413
.0990	212	23.05	.00416
	401	24.6	
.1217	222	29.22	.00416
.1495	330	36.0	.00415
.1628	331	39.31	.00414
.1726	510	41.3	.00419
.1900	223	45.75	.00425
.2038	430	49.3	.00423
.2339	521	55.31	.00423
.2413	204	58.2	.00424
.2563	602	61.2	.00419
.2731	530	65.33	.00418
.3110	404	74.3	.00419
.3336	414	80.9	.00412
.3542	541	84.61	.00419
.3708	334	88.9	.00417
.3844	721	92.6	.00415
.3936	542	94.52	.00416
.4346	405	103.95	.00418
.4519	731	108.61	.00416
.4692	820	112.0	.00419
.4778	642	114.52	.00417
.5203	822	125.22	.00416
.5333	216	128.3	.00416
.5679	316	136.3	.00417
.5969	660	144.0	.00415
.6389	743	153.75	.00415
.6679	931	159.31	.00419
.7497	317	179.3	.00418

Av. 0.00418

$a_0 = 11.90$

$c_0 = 6.54 \quad c/a = 0.55$

$$\text{Calculated sp. gr.} = \frac{9 \times 131.6 \times 1.649 \times 10^{-24}}{\frac{1}{2}\sqrt{3} \times 0.55 \times (11.90)^3} = 2.434,$$

assuming 9 molecules to unit cell.

Observed specific gravity = 2.462 ± 0.002

* Received March 22, 1937; the correction figures were made by S. S. Cole, National Lead Co., Titanium Division, South Amboy, N. J.

[1] *Jour. Amer. Ceram. Soc.*, **18** [2] 58–61(1935).

* For complete data see Table II, Cole, Scholes, and Amberg, *loc. cit.*, p. 60.

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June, 1937

16—6

Abrasives

Abrasives for metal polishing. Cyril S. Kimball. *Metal Cleaning & Finishing*, **9** [2] 147–53; [3] 233–34 (1937).—Abrasives can be classified as hard, intermediate, and soft. K. discusses, under hard abrasives, silicon carbide, fused alumina, corundum, emery, garnet, and quartz; as intermediate abrasives, feldspar, pumice, pumicite, silica, tripoli, and rottenstone; and under soft abrasives, Vienna lime, crocus, rouge, chromium oxide, diatomite, and calcium carbonate. See *Ceram. Abs.*, **15** [1] 1 (1936). E.J.V.

Machine lapping for finest finishing. E. Pallas. *Oberflächentech.*, **14** [4] 37–39 (1937).—Honing produces, in bearings, such exact fitting of the journal in the bushing that practically no wear occurs in use. Procedure, equipment, and material used for the latter and lapping materials are discussed. M.H.

Polishing and buffing of stainless steels. R. S. Leather. *Metal Cleaning & Finishing*, **7** [9] 437–42; [10] 491–94 (1935).—The procedures employed in the polishing and buffing of stainless steels can best be understood by discussing (1) the general properties of stainless steels which inherently necessitate special finishing methods to overcome the difficulties involved, (2) finishing steps in the order in which they are commonly performed, from rough polishing through scratch brushing and buffing, and (3) specific problems in the finishing of certain stainless steel articles. Typical methods used by manufacturers of stainless steel products are described. Illustrated. E.J.V.

Properties of the newer hard carbides. Henry R. Power. *Metal Cleaning & Finishing*, **9** [1] 61–62 (1937).—The specialized uses to which the newer hard carbides may be put has made them important materials in the abrasive industry, despite their comparatively high price. The physical and chemical properties of these new materials, tungsten, titanium, tantalum, columbium, and zirconium carbides, are briefly discussed. E.J.V.

PATENTS

Abrading tool. J. B. Hadaway (United Shoe Machinery Corp.). U. S. 2,076,776, April 13, 1937 (June 20, 1935).

Abrasive. Pierre Neven. Ger. 626,512, Feb. 27, 1936; Cl. 80*b*. 11; *Chem. Abs.*, **30**, 5747 (1936).—A mixture of 20 to 30% diamond dust is heated with 80 to 70% of Fe powder to sintering temperature, and the product is hot pressed.

Abrasive article. D. E. Webster (Norton Co.). U. S. 2,076,833, April 13, 1937 (April 13, 1935). An abrasive article comprises a main body portion of an organic bond and abrasive grains having a grinding face and a rough side face, the latter being composed solely of a surface layer of abrasive grains partially imbedded within the bond and having different abrading characteristics from the abrasive grains within the body portion and providing sharp abrasive teeth projecting from the sides of the article.

Abrasive articles and their manufacture. Norton Grinding Wheel Co., Ltd. Brit. 462,966, April 1, 1937 (Nov. 23, 1935).

Abrasive body and method of making. L. H. Milligan (Norton Co.). U. S. 2,077,366, April 13, 1937 (Aug. 3, 1935). The method of making an abrasive body of hard granular material bonded with a metallic bond comprises selecting a hard abrasive, providing a quantity thereof in abrasive particle size, selecting a metal alloy which, when molten, has the same specific gravity within close limits

as that of the abrasive material selected, melting the alloy, bringing together a quantity of the abrasive and a quantity of the alloy, and thereafter cooling.

Abrasive drum for leather surfacing machines, etc. G. M. CURTIN (Behr-Manning Corp. and Curtin and Hebert Co., Inc.). U. S. 2,076,193, April 6, 1937 (Nov. 21, 1936).

Abrasives, refractories, and insulating materials. JANIK DIRATS AND VLADIMIR DITERICHS. Fr. 798,245, May 12, 1936, *Chem. Abs.*, **30**, 7300 (1936).—The primary materials are bound together by causing, by several successive and uninterrupted phases, a crystallization between the particles or crystals of the primary material; thus a monolithic crystallization mass of perfect crystalline stability and physicochemical equilibrium is produced. The binders are composed of several salts capable of crystallizing together to form mixed isomorphous crystals or zone crystals.

Abrasive wheel. EDWARD VAN DER PYL (Norton Co.). U. S. 2,077,345, April 13, 1937 (Aug. 2, 1935). An abrasive body comprises diamond grain united with a bond comprising aluminum in the neighborhood of 40 parts and silicon in the neighborhood of 60 parts, the aluminum and the silicon being sintered together and not completely alloyed.

Abrasive wheel and mounting. H. W. H. BETH (Norton Co.). U. S. 2,076,806, April 13, 1937 (Jan. 4, 1936).

Apparatus for measuring the resistance of substances to grinding. I. KUHN AND BRABENDER GES. Brit. 461,843, March 10, 1937 (Feb. 15, 1935).

Cutlery grinder. N. H. ADAMS (General Electric Co.). U. S. 2,077,195, April 13, 1937 (July 12, 1934).

Diamond embedded abrading tools and methods of manufacturing. F. H. WILLEY. Brit. 462,809, April 1, 1937 (July 16, 1935).

Form tool grinding fixture. HARRY PELPHREY (Michigan Tool Co.). U. S. 2,076,742, April 13, 1937 (May 7, 1930).

Grinding element for and method of making spline couplings. JOHN EDGAR (Barber-Colman Co.). U. S. 2,077,100, April 13, 1937 (Feb. 25, 1933).

Grinding machine. W. L. BRYANT (Bryant Chucking Grinder Co.), U. S. 2,076,808, April 13, 1937 (Nov. 2, 1932). C. G. FLYGARE (Norton Co.), U. S. 2,077,359, April 13, 1937 (April 8, 1936). S. A. STRICKLAND. U. S. 2,076,682, April 13, 1937 (Sept. 28, 1931).

Grinding spindle drive for universal grinding machines. L. KELLENBERGER (trading as L. Kellenberger & Co.). Brit. 462,707, March 24, 1937 (April 15, 1935).

Grinding wheel truing apparatus. G. E. HULBERT (Norton Co.). U. S. 2,077,363, April 13, 1937 (Aug. 7, 1935).

Hole lapping tool. O. C. KOMMER. U. S. 2,075,397, March 30, 1937 (May 1, 1936).

Lapping machine. H. S. INDGE AND G. E. HULBERT (Norton Co.), U. S. 2,077,364, April 13, 1937 (April 9, 1936). A. J. STRONG. U. S. 2,076,601, April 13, 1937 (April 18, 1935).

Manufacture of abrasive articles. N. P. ROBIE (Carborundum Co.). U. S. 2,076,517, April 6, 1937 (July 11, 1931). A moldable and heat-hardenable abrasive mixture comprises abrasive granules coated with a potentially reactive liquid resin, and a finely divided solid and potentially reactive resin.

Manufacture of abrasive-coated articles. W. J. TENNANT (R. C. Benner and R. L. Melton). Brit. 462,698, March 24, 1937 (Sept. 13, 1935).

Manufacture of abrasive-coated fabric. CARBORUNDUM CO. Brit. 462,696, March 24, 1937 (Oct. 4, 1934). W. J. TENNANT (R. C. Benner and R. L. Melton). Brit. 462,697, March 24, 1937 (Sept. 13, 1935).

Marble refacing machine. LOWELL STETLER. U. S. 2,075,369, March 30, 1937 (Sept. 30, 1935).

Method and machine for grinding or lapping bearing rolls. A. B. EINIG (Motch & Merryweather Machinery Co.). U. S. 2,075,104, March 30, 1937 (Feb. 6, 1935).

Method of making a rough-sided rubber-bonded abrasive wheel. PEHR JOHANSON (Norton Co.). U. S. 2,076,846, April 13, 1937 (Jan. 4, 1936).

Method and means for dressing grinding wheels used for form grinding. COVENTRY GAUGE & TOOL CO., LTD., H. H. HARLEY, J. YORSTON, AND J. E. WAINWRIGHT. Brit. 461,969, March 10, 1937 (Aug. 24, 1935).

Oscillating grinder. F. D. VAN NORMAN (Van Norman Machine Tool Co.). U. S. 2,076,508, April 6, 1937 (April 9, 1936).

Production of resin-coated abrasive grain for abrasive articles. W. J. TENNANT (Carborundum Co.). Brit. 461,437, March 3, 1937 (Aug. 16, 1935).

Rail grinder. MILBURN MOORE (Chester F. Gailor). U. S. 2,076,089, April 6, 1937 (Sept. 15, 1934).

Surface grinding machines. LUMSDEN MACHINE CO., LTD., E. G. BLAKE, W. S. LUMSDEN, AND J. H. STANIER. Brit. 461,541, March 3, 1937 (Aug. 5, 1936).

Valve seat lapping machine. VICTOR MANCUSO (Axelson Mfg. Co.). U. S. 2,075,216, March 30, 1937 (Oct. 14, 1935).

Art and Archeology

Beauty in glass. FRANK THONE. *Sci. News Letter*, **31** [834] 214–15, 218 (1937); see *Bull. Amer. Ceram. Soc.*, **15** [11] 405–407 (1936). W.F.F.

Ceramic valentine. ANON. *Sydney Mail*, p. 14 (Feb. 10, 1937).—A comic valentine made by the artist, George Pratt, more than a century ago is reproduced. The picture is that of a man made entirely of ceramic ware; the body is a vase, the legs are plates and jugs, the arms trays, the hands teapots, and the hat is a pudding basin; in the mouth is a clay pipe. H.H.S.

Eumorfopoulos collection of Chinese art. R. L. HOBSON. *Brit. Museum Quart.*, **10** [4] 182–83 (1936).—This valuable collection, now a national possession, is on view in its entirety for the first time at the Victoria and Albert Museum, London. It is to be divided among various museums and can not come together again until the Museum of Oriental Art is brought into existence. H.H.S.

Porcelain signs produced by the Kleylein process. HENRY BLASHFIELD. *Enamelist*, **14** [5] 19–20 (1937).—

The Kleylein process, which originated in Germany, is a printing process involving the transfer of a colored photograph, painting, or other piece indirectly through the medium of a silk paper screen. The colored picture is photographed through appropriate color filters to resolve it into its various color components, and zinc electros are made from each photo. The method of producing the colored porcelain sign from the print on silk paper is described in detail. E.J.V.

STANDARDS

Proposed commercial standard for colors for bathroom accessories. As submitted by the National Retail Dry Goods Assn. *Nat. Bur. Standards, TS*-2353. 3 pp. March 15, 1937. This standard covers seven colors adopted as standard for bathroom accessories, provides a standard sample plan for control of these colors at the source, specifies a method for visual comparison, and supplies a means for identification of standard colors from producer to user. R.A.H.

Proposed commercial standard for colors for kitchen accessories. As submitted by the National Retail Dry Goods Assn. *Nat. Bur. Standards, TS*-2352. 3 pp. March 15, 1937. This standard covers six colors adopted as standard for kitchen accessories, provides a standard sample plan for control of these colors at the source, specifies a method for visual comparison, and supplies a means for identification of standard colors from producer to user. R.A.H.

PATENTS

Designs for:

Cup. KARL BAYREUTHER (Rosenthal China Corp.). U. S. 103,907, March 30, 1937 (Dec. 29, 1936).

Electric wall bracket. R. G. COWAN (Pass & Seymour, Inc.). U. S. 103,802, March 30, 1937 (Dec. 17, 1936).

Goblet. E. W. NEWTON (Imperial Glass Corp.). U. S. 103,826, March 30, 1937 (Feb. 5, 1937).

Hollow glass building block. W. P. ZIMMERMAN (Owens-Illinois Glass Co.). U. S. 104,127, April 13, 1937 (Jan. 31, 1936).

Plate. VINCENT BROOMHALL (Edwin M. Knowles China Co.). U. S. 103,923, April 6, 1937 (Feb. 16, 1937).

Cements

Alite. K. KOYANAGI. *Zement*, **23** [43] 633–35 (1934).—K. manufactured, on a technical scale, a clinker rich in alite and came to the following conclusions: (1) alite is tricalcium silicate; (2) iron oxide and alumina are not needed as constituents of Portland cement but are necessary fluxes, allowing the formation of alite at a relatively low temperature; (3) the substitution of fluorspar or gypsum for iron oxide and alumina makes it possible to obtain technically an excellent cement, very rich in alite and of extraordinary strength; and (4) from the economical viewpoint, the experiences remain undecisive but the amelioration of quality is certain. F.E.V.

Attempt to obtain "cold" unfired glazes. P. I. GALKIN AND YA. M. KHANANOV. *Stroitel. Materialy*, No. 2, pp. 49–56 (1936).—Several methods of low-temperature glazing of cement facing tile were worked out. White glaze-like coverings were obtained by settling silica from soluble glass by treating it with a dilute solution of ammonium chloride. Nitro-colors and nitro-lacquers can be used to obtain coverings of varied colors and shades, but such tile can be used only for internal facing. Deep shades can be obtained by using phenolformaldehyde plastics. Varied colored tile of light shades can be obtained by using a finely ground Portland cement mixed up with a white filler and pigment. P.B. & E.S.

Colloid-chemical character of mixtures of cements and method for determining the best relations between the composition of the components. M. A. RESHETNIKOV. *Kolloid. Zhur.*, **1**, 525–40 (1935); *Chem. Abs.*, **30**, 8553 (1936).—The effects of concentration of H_2O, of relative proportions of various components, and of additions of benzene, Cl_2, and NH_3 on the heats of wetting, the activity of the hydraulic components, the stability of the suspensions, and the strength of the final product are discussed and illustrated by data on various cements, stuccos, etc. Building cements must be composed of relatively coarsely dispersed particles of components bearing opposite electrical charges. Mutual coagulation takes place to produce an agglomerate near the isoelectric point. Solidification is conditioned by chemisorption and reaction leading to microcrystal formation depending upon the surface properties of the components.

Lime saturation and chemical composition. A. R. STEINHERZ. *Rev. Matériaux Construction Trav. Publics*, No. 328, pp. 3–8 (1937).—The growing importance of high-resistance cements has exercised great influence on research for a general formula for the best composition of artificial Portland cements. Several chemists have proposed formulas where the lime content is represented as a function of the other constituents of clinker. Several formulas are studied. The Lea and Parker formula is $CaO_{max} = 2.8SiO_2 + 1.18Al_2O_3 + 0.65Fe_2O_3$ (*Ceram. Abs.*, **15** [1] 7 (1936)); the excellent agreement of this formula with the "Cementation Index" of Eckel and the formula of Kühl (*ibid.*, **15** [7] 199 (1936)) is evidence that a definite relation can be established between the admissible lime content and the percentages of other constituents of clinker. Parallel with research on the best chemical composition of artificial Portland cements is the search for a good graphic method to express this composition. The geometric figuration for four components as a cube or, with the omission of one component, a triangle, their developments, and a method for calculating the compositions of cements are clearly explained. M.V.C.

Magnesia of Portland cement: II. Y. SANADA AND G. NISHI. *Jour. Soc. Chem. Ind. Japan*, **40** [1] 16–17B (1937).—The effect of magnesia on the preparation of $2CaO \cdot Fe_2O_3$ was studied. It was concluded that (1) calcium ferrite and magnesium ferrite are insoluble, and free magnesia is soluble in a 5% solution of acetic acid in methyl alcohol; and (2) calcium ferrite and magnesium ferrite were formed at 800°C. $2CaO \cdot Fe_2O_3$ existed at 1200° and 1400°. In one sample $MgO \cdot Fe_2O_3$ existed at 1400°, the remaining MgO existing free in the clinker.

For Part I see *Ceram. Abs.*, **16** [4] 109 (1937); see also *ibid.*, **14** [9] 209 (1935). M.V.C.

Preparation and properties of acid-resistant cement. E. M. KHANIN. *Koks & Khim.*, **1935**, No. 11, pp. 51–53; *Chem. Abs.*, **30**, 7809 (1936).—The cement contains acid-resistant powder 100 g., Na_2SiF_6 3 to 4 g., and 17 to 20 cc. of aqueous Na silicate (density 1.36; $Na_2O:SiO_2 = 1:2.8$ to 3.0).

Technical mortar studies on silicates and aluminates of lime. ANON. *Tonind.-Ztg.*, **61** [1] 4–5 (1937).—The behavior of separate constituents of Portland cement clinker was studied by P. Schläpfer (Twenty-fourth Yearly Report of the Union of Swiss Cement, Lime, and Gypsum Manufacturers, 1934, *Ceram. Abs.*, **16** [2] 58 (1937)). The reactions of setting of tricalcium-silicate grains were studied under a microscope. On the surface of a hardened sample stored for $3^1/_2$ months in water, S. found crystals of hydrate of lime of 1 to 2 mm. In the study of the cause of hydration, it was found that the quantity of free lime is a graduation for the extent of the hydration. The hydration can not be accelerated by increasing the water content or by water storing; a fine grain size is necessary for most complete hydration. Tests on the amount of water of hydration of hydrated samples showed vapor-pressure isotherms, proof of the presence of a gel. The strength of tricalcium silicate is compared graphically with other materials. The study of the resistance to water of hardened tricalcium silicate showed that not only the free calcium hydroxide but also the combined lime gradually dissolved out until a compound remained which contained about 1 mol. calcium oxide to 1 mol. silicic acid. Tests on dicalcium silicate showed a very slow setting. Study of monocalcium aluminate, the main ingredient of aluminous cements, showed that combined monocalcium aluminate hydrate can be destroyed by storing in water. M.V.C.

White cement. I. YA. SLOBODYANIK, V. E. KORDYUKOV, AND L. A. LEVENZON. *Tsement*, **4** [6] 32–34 (1936).—Colorless cement is obtained by adding NH_4Cl or $NaHSO_4$ + NaCl to the slurry in a quantity sufficient for the formation of $FeCl_3$, which volatilizes at the temperature of clinker formation. A sufficiently light clinker is obtained from natural marl containing 1 to 1.5% of iron, if quickly cooled, without a change in the flow sheet. White cement can be obtained from lime marl containing less than 0.5% iron by firing to the formation of dicalcium silicate with a subsequent quick cooling. Quick cooling of clinker delays the transformation of the β-modification of $2CaO{\cdot}SiO_2$ to the γ-modification and quickens the hydration of dicalcium silicate, at the same time making the grinding of clinker easier. P.B. & E.S.

Enamel

Boiling water-acid rinses in pickle room processing. D. L. BENSINGER. *Enamelist*, **14** [6] 5–10 (1937).—B. discusses the various forms of contamination that may occur in putting ware through the pickle room and which may cause defects in the finished enameled piece. In kitchen-ware production it is often a case of running one-coat ware, and this necessitates the cleanest possible ware coming from the pickle room. Experiments in production work show that by using a boiling hot-water rinse directly after the acid tank, followed by a cold-water rinse and a weak neutralizer, a great reduction in defects from contaminations has resulted. The procedure followed in using this rinse is discussed, and results obtained are described in detail. E.J.V.

Drainage of vitreous enameling reagents. TOKIJI UCHIDA AND FUMIO TAMAKI. *Repts. Imp. Ind. Research Inst., Osaka, Japan*, **14** [7] 1–78 (1933); *Chem. Abs.*, **30**, 7297 (1936).—There is a constant relationship between the added salt and the yield value of an enameling reagent. NaF, BaF_2, and $BaSiF_6$ give excellent "setting," whereas an addition of clay or a decrease of H_2O content does not improve the drainage quality.

Enamelware for cooking utensils; London official tests. ANON. *Analyst*, **61** [729] 840 (1936).—The annual report of the London County Medical Officer of Health includes the results of inspection of enamelware. In 1935, 232 samples were examined; five were rejected for nonresistance to acid and six, for containing Sb. The percentage rejected, 4.7%, as against 25% for the preceding year, shows the great improvement in quality of the articles supplied by contractors to the public institutions under the County authority. H.H.S.

Essentials of good pickling practice. P. R. RUSSELL. *Metal Cleaning & Finishing*, **9** [2] 113–16; [3] 197–200 (1937).—In the process of pickling iron and steel in its many diversified forms, three main variable factors must be considered, *viz.*, time, temperature, and acidity. R. discusses pickling time, temperature and temperature control, acid content and control of pickle solutions, acid-testing methods, pickle-control charts, pickle-room layout, rinsing of pickled material, heating and agitation of pickling solutions, general care of equipment, and pickling efficiency. E.J.V.

Gas-fired radiant tubes installed in continuous furnace. ANON. *Enamelist*, **14** [4] 15–19 (1937).—Fuel-cost savings of approximately 50% are indicated in the operation of the continuous furnace transformed into one of gas-fired radiant tubes at the Granite City, Ill., plant of the National Enameling & Stamping Co. A slightly faster firing rate with unchanged quality of the ware has also resulted. Full details of the placing of the tubes and the operation of the furnace are given. Illustrated. E.J.V.

Gas opacification in enamel. HANS HADWIGER. *Glashütte*, **67** [9] 151–53 (1937).—Excellent results are obtained with the gas opacification method of I. Kreidl. A 78 to 82% opacification is obtained in all ware, and it is superior to opacification obtained by ordinary methods. Luster, color, and appearance of the ware are excellent. The color is pure white while the appearance is porcelain-like. The coating power of this enamel is similar to that of ordinary enamels used for comparison purposes. The boiling strength was tested by Kinzie's method; the enamel showed an especially high thermal resistance. Acid stability, tested with a 10% solution of acetic acid according to the method of Karmaus, was excellent. M.V.C.

Glass-lined steel equipment. P. S. BARNES. *Ind. Eng. Chem.*, **29** [4] 378–79 (1937); see *Ceram. Abs.*, **16** [3] 84 (1937). F.G.H.

Increasing the adherence of the enamel layer on enameled ironware. TOKIJI UCHIDA AND FUMIO TAMAKI. *Repts. Imp. Ind. Research Inst., Osaka, Japan*, **16** [5] 1–30 (1935); *Chem. Abs.*, **30**, 7806 (1936).—Ba borate was found to be useful as a ground glaze for increasing the adherence. A detailed study was made to find the optimum temperature, length of heating, amount of the reagent, mode of pore formation, etc.

Influence of furnace gases on porcelain enameling. G. H. MCINTYRE. *Enamelist*, **14** [4] 6–10 (1937).—From work done in the laboratory and under production conditions, it can be said that the nearer the furnace atmosphere approaches that of normal air, the better will be the finished enamel product. Small traces of carbon dioxide, water-vapor, and fluorides are not injurious, but the limit is very low, *i.e.*, approximately 3 to 4% for water-vapor and 4% of acid gases by volume. Cast-iron enamels are easily harmed by these gases, and in furnaces firing such enamels extreme care must be exercised to keep a circulation of air through the muffle. E.J.V.

Porcelain enameling in Japan. MARVIN O. LEWIS. *Enamelist*, **14** [6] 11–13 (1937).—A brief description of the Kiyosu Shoten factory of Tokyo and of the Nagoya Horotekki Seisakoshu Co., at Nagoya, about 300 miles west of Tokyo, is given. Both plants produce pots, pans, and pails of Japanese steel, most of the enameling being done by the dipping process. Coal-fired muffles of small capacity are used in both plants. Nearly all of the raw materials for the enamels are imported. E.J.V.

Powder enameling by immersion. HEINRICH KIRST. *Glashütte*, **67** [9] 153–57 (1937).—The method of enameling small articles heated to redness by immersing them in finely powdered enamel is discussed in detail. Analyses of eight enamel batches are given. See *Ceram. Abs.*, **13** [8] 201 (1934); **14** [3] 62 (1935). M.V.C.

Reaction of adhering oxides on firing of sheet-iron enamel. A. DIETZEL. *Sprechsaal*, **69** [53] 777 (1936).—A correction of an error which appeared in the original work dealing with the subject is given. See *Ceram. Abs.*, **14** [5] 107 (1935). M.V.C.

Sioglur, a new enamel raw material. RICHARD ALDINGER. *Glashütte*, **67** [9] 157–59 (1937); see "Technical—," *Ceram. Abs.*, **15** [9] 270 (1936); **16** [1] 10 (1937). M.V.C.

Standardization of test of acid resistance of enamel. H. HECHT AND B. OLDENBURG. *Keram. Rundschau*, **43** [23] 263 (1935).—The investigations of Dawihl (*Ceram. Abs.*, **15** [9] 270 (1936)), Karmaus, and Beyerlein have shown that the test with one acid only is insufficient. Experiments with acetic, oxalic, formic, tartaric, and lactic acids were made. Enameled plates were replaced by rods with a hemispheric end. The figures agree with each other, although there is much difference in the energy of the chemical action. The use of 5% lactic acid is advocated for the normal test. See *Ceram. Abs.*, **16** [1] 10 (1937). F.E.V.

Stores in porcelain enamel. ANON. *Enamelist*, **14** [4] 20–21 (1937).—Four new porcelain enamel-front stores, opened by the Producers Milk Co., Cleveland, Ohio, during 1936, are attractive and easily identified by a standardized color scheme of ashburn green, black, white, and Chinese red. E.J.V.

Technique of decoration of enamelware. RICHARD ALDINGER. *Glashütte*, **66** [52] 873–76 (1936).—Methods used to apply colored fused enamels for decoration are described in detail. The composition, manufacture, and properties of these enamels are discussed. M.V.C.

PATENTS

Enameling metal. R. R. TANNER (Metal Finishing Research Corp.). Can. 360,972, Oct. 6, 1936; *Chem. Abs.*, **30**, 8554 (1936).—An article having an iron surface is coated with substantially insoluble phosphates, the phosphates are covered with an air-excluding coating of glass-forming materials and heated above 1000°F, and the glass-forming materials are fired into a vitreous enamel coat upon the phosphate coating.

Heat-resisting finish. M. L. MICHAUD (Metal Finishing Research Corp.). U. S. 2,076,183, April 6, 1937 (Feb. 25, 1935). A black finish consists of sodium silicate and filler consisting of black oxide of cobalt and black oxide of iron, the sodium silicate having a ratio of approximately 1 part of Na_2O to 3.42 parts of SiO_2.

Method of making enameled metal articles. R. R. TANNER (Metal Finishing Research Corp.). U. S. 2,076,869, April 13, 1937 (Nov. 22, 1930). A method of providing an iron article with a vitreous-enamel coating comprises providing the surface of the iron with a coating of substantially insoluble phosphates and firing upon the coating of phosphates a vitreous enamel while maintaining the phosphate coating unchanged by protecting the phosphate coating from contact with air to form a vitreous enamel coat upon the phosphate coating.

Porcelain enamelware and method of forming. D. D. WHEELER (Erie Enameling Co.). U. S. 2,076,329, April 6, 1937 (Jan. 15, 1932). In the method of producing an article having a vitreous-enamel finish, the steps comprise depositing on an article base a wet coat of vitreous-enamel material, drying the coat at least to some extent, forming a rough surface on the dried coat by depositing globules of liquid enamel material, the dried coat absorbing at least part of the liquid component from the globules and thereby drying them, applying to the resulting dried masses at an angle a color stable at the firing temperature and contrasting with the predetermined color of the masses, and firing the so-treated article to produce a fused surface having the visual appearance of depth and roughness.

Glass

Ancient glasses. RENATO MORETTI. *Centro Studi Ceram.*, **3** [2–6] 25–26 (1936).—In B.C. 4400 to 4200 the Egyptians were using colored glasses and enamels. According to Neumann's analyses of ancient glasses (*Ceram. Abs.*, **5** [3] 86 (1926); **6** [5] 165; [8] 330 (1927); **7** [5] 275; [9] 610 (1928)), cobalt was not found, and blue coloring was obtained by copper oxide or copper and ferric oxides mixed. (Cobalt and chrome were first used in glasses in

Murano in 1443.) Manganese, zinc, lead, and tin were also used. The way in which the high fusing temperatures were reached and the refractories used are not known. M.V.C.

Carbon and sulfur yellow glasses. LUDWIG SPRINGER. *Sprechsaal*, **69** [50] 735–36 (1936).—Theoretical conclusions from the experiments made show that (1) carbon alone does not color ordinary glasses, but with the simultaneous addition of sulfur it acts because of its reduction as a stabilizer; (2) iron oxide is not required to obtain a stronger coloring with sulfur compounds or sulfate and charcoal, but it promotes and intensifies coloring; (3) in other glasses in which intensive coloring results in the absence of larger amounts of iron oxide, alkali sulfides must be employed. Results for practice show that (*a*) a small addition of charcoal or iron oxide is advantageous when coloring with sulfur or sulfur compounds; they stabilize the coloring and therefore less pigment is needed; (*b*) when coloring with sulfate and charcoal, small amounts of iron oxide seem to injure the yellow-brown color and only larger amounts of it promote the coloring. See *Ceram. Abs.*, **16** [5] 145 (1937). M.V.C.

Chemistry of colored glass: I. WOLDEMAR WEYL. *Glass Ind.*, **18** [3] 73–78 (1937).—Taking up the theoretical considerations of the origin of the absorption spectrum, W. discusses the change in the fine structure, the shift of the absorption band, and the occurrence of a new band. The solvation of the colored ions gives rise to a change in fine structure and to a shift of the absorption bands in glasses relative to those in aqueous solutions. The dissociation-association equilibria between coloring complexes are taken up, showing the influence of the base glass, temperature, and heat treatment. See *Ceram. Abs.*, **14** [6] 135, 150 (1935). E.J.V.

Commercial-scale glass equipment. W. A. KATES. *Ind. Eng. Chem.*, **29** [4] 398–401 (1937).—The use of glass for the production of commercial-scale piping, heat exchangers, fractionating and absorption equipment, and other special types of corrosion-resistant apparatus is briefly described. Illustrated. F.G.H.

Computing tensile strength of glass; a probability problem. W. HARRIES. *Z. Tech. Physik*, **18** [2] 48–54 (1937).—The tensile strength of glass can not be characterized by one constant only, and it can not be obtained from increase or length of load. The tensile strength can be dealt with, however, from the standpoint of probability. A formula is presented which contains two constants and which shows satisfactory agreement of computed and observed values. No conclusion can be drawn from the formula as to phenomena which cause or accompany the breaking of glass. W.M.C.

Effect of condition of the melt when worked on glass quality. ANON. *Glashütte*, **66** [17] 303–304 (1936).—The importance of the purity of materials used and of the homogeneity of the melt on the finished glass product is discussed. Illustrated. M.V.C.

Effects of exposure of various glasses to radon. JOHANNA WIESTHAL. *Sitzber. Akad. Wiss. Wien, Math.-naturw. Klasse, Abt. I*, **145**, 239–60 (1936); abstracted in *Chem. Zentr.*, **1937, i**, 1369; for abstract see *Ceram. Abs.*, **16** [2] 59 (1937). M.V.C.

Electrically heated glass-press furnace. K. MITLEHNER. *Sklarske Rozhledy*, **12**, 20–24 (1935); *Chem. Abs.*, **30**, 7459 (1936).—A furnace for pressed glassware is described.

Even grinding of glass pipes and glass vessels. H. DRAUTZ. *Chem.-Ztg.*, **60** [87] 886 (1936).—An emery cloth with a rotating movement is recommended to obtain exact angular ends in glass pipes. This method is especially suitable for cast glass. M.V.C.

Fused silica ware; laboratory equipment for fuel analysis. ANON. *Engineer of India*, **3** [9] 275–76 (1936).—A wide range of laboratory and special apparatus of Vitreosil, fused silica ware, is being produced by the Thermal Syndicate, Ltd. The list of laboratory apparatus now includes tubes, special combustion tubes with a transparent window, combustion boats, crucibles (including special varieties for calorimeter bombs), dishes, casseroles, assay trays and cups, coils, retorts, flasks, triangles, plates, rods, muffles of many different shapes, and general apparatus specified in standard methods of fuel analysis. There are three forms of fused silica, opaque, translucent, and transparent, according to the nature of the original silica. The degree of transparency depends merely upon the amount of enclosed gas. See "Properties—," *Ceram. Abs.*, **15** [9] 272 (1936); "Vitreosil—," *ibid.*, [10] 299; "Fused silica—," *ibid.*, **16** [4] 113 (1937). A.P.S.

Glass as exchange material. G. SCHOTT. *Metallwirtschaft*, **15** [48] 1111–12 (1936).—Attention is called to the great progress which has been made in recent years in mechanical and working properties of glass which make it a suitable substitute for metals in many cases. The special glass "Duran" of Jena has a density of 2.32, tensile strength 800 kg./cm.², compressive strength 11,200 kg./cm.², impact bending strength 3.09 cm.–kg./cm.², linear expansion coefficient 3.6×10^{-6}, and a heat conductivity of 0.0023. M.H.

Glass manufacture in Australia. ANON. *Sydney Morning Herald* [Ann. Finance Supp.], Feb. 12, 1937.—Because of a trade agreement with Belgium, Australian manufacturers had to restrict their output of sheet glass in 1936. Only 52% of the Commonwealth demand was met by local firms; Belgium supplied the greater part of the remainder and Britain the rest. Increased building activity resulted in increased sale of plate and sheet glass. H.H.S.

Glass pipe conduits for chemical heavy apparatus. TH. ZIENER. *Chem.-Ztg.*, **60** [87] 883–86 (1936).—The advantages of using glass conduits in chemical apparatus are discussed. See *Ceram. Abs.*, **16** [4] 114; [5] 145 (1937). M.V.C.

Glass wool. BÜRGEL. *Chem.-Ztg.*, **60** [95] 961–64 (1936).—A review is given of the manufacture, properties, and application of glass wool. See *Ceram. Abs.*, **16** [1] 12 (1937); "Recent—," *ibid.*, [5] 147. M.V.C.

Glass wool and diatomaceous earth. H. WAHL. *Feuerungstechnik*, **24** [12] 210–13 (1936).—Requirements of insulating materials are enumerated, and diatomite and glass-wool insulation are compared. The effective thickness of insulating layers is discussed, and tabular data are given. M.V.C.

History of the Zeiss Works to the time of the death of Ernst Abbé. M. VON ROHR, M. FISCHER, AND A. KÖHLER.

Forschungen zur Geschichte der Optik, **2**, 1–119 (1936); *Jour. Soc. Glass Tech.*, **20** [82] 407A (1936).—Carl Zeiss opened a small optical workshop in Jena in November, 1846. Here he worked alone, did repairs, and sold magnifying glasses. His stock-in-trade was purchased with 100 talers which he borrowed from his father. From this humble beginning grew the present famous Carl Zeiss works.

Increasing production capacity of Fourcault machines. I. I. Kitaigorodskiĭ, V. S. Yakopson, T. N. Keshash-'yan, and F. G. Solinov. *Keram. & Steklo*, **12** [12] 12–20 (1936).—Data are given on changes made in Fourcault machines to increase their output. M.V.C.

Increasing the speed of drawing of Fourcault glass and struggles with glass streaks. Ya. P. Gusakov. *Keram. & Steklo*, **12** [12] 20–22 (1936).—The use of floaters prevents the formation of streaks and sharply increases the rate of drawing of the glass. Streaks appear periodically in Fourcault machines at the extreme right and left. They are due to a thermal inhomogeneity of the glass in the critical temperature interval, which produces sharp differences in the viscosity of glass, and to straight and turbulent glass flows which break the glass layers and form streaks in it. The working temperatures in the Fourcault channel should be lowered and must be based on the analysis of the glass mass. M.V.C.

Manufacture of assorted glassware in U. S. A. P. Zak. *Keram. & Steklo*, **12** [12] 5–12 (1936).—Machines used for the manufacture of pressed glassware in the U.S. are briefly described. Illustrated. M.V.C.

Mount Pleasant Glass Works, 1844–1870. L. E. Thiess. *Ceram. Age*, **28** [5] 147–48 (1936).—The history of the glassworks is given. Excavations made at the site of the former village of Mt. Pleasant (near Saratoga, N. Y.) yielded many fragments of mineral water bottles and other glass made at this plant. Illustrated. L.E.T.

Rate of solution of alkali-boron glasses. R. L. Müller and C. V. Weinstein. *Acta Physicochim. U.R.S.S.*, **3**, 465–502 (1935); abstracted in *Chem. Zentr.*, **1937**, **i**, 967; see "Kinetics—," *Ceram. Abs.*, **16** [1] 13 (1937). M.V.C.

Series of glasses colored by sulfurous matter: I. K. Fuwa. *Jour. Soc. Chem. Ind. Japan*, **40** [1] 15B (1937).—The relationship between the sulfur content and the intensity of color was studied. Results were as follows: (1) Glasses in which the basic oxide component (R″O) in the general formula ($1.3R'O{\cdot}R''O{\cdot}6SiO_2$) corresponds to PbO were not colored by sulfur. (2) Glasses in which the alkali oxide component (R′O) corresponds to Na_2O were lighter colored than those in which the alkali oxide component is K_2O. (3) Glass prepared from the batch containing 1% sulfur together with 1% nitrate had no yellowish coloring. Glass from the batch containing 1% sulfur and 1% potassium tartrate showed a brownish color. Glass from the batch with 1% sulfur and 1% arsenious oxide had a weak color. (4) The nitrate showed stronger action than the arsenious oxide toward the sulfur in the glass. M.V.C.

Shaping glass by grinding and by machining with widia. E. O. Schulz. *Glas & Apparat*, **17** [26] 233–35 (1936); **18** [1] 3–5; [2] 11–12 (1937).—The various methods and processes for shaping glass in the hot or cold state are discussed, particularly those for the cold state. The mechanisms of grinding and turning with tools of widia metal (tungsten carbide with Co additions) are described in detail. M.H.

Silica glass. R. W. D. *Verre & Silicates Ind.*, **8** [4] 37–40 (1937).—Silica exists in different crystalline forms, *viz.*, quartz, tridymite, cristobalite, and forms derived from them: α- and β-quartz; α-, β_1-, and β_2-tridymite; and α- and β-cristobalite. The physical properties and applications of fused quartz and fused silica are described. M.V.C.

Transmission of light through a pile of parallel plates. R. A. Hull. *Proc. Phys. Soc.* [London], **48**, 574–75 (1936).—The transmission of light through a pile of transparent plates is calculated by a simple method which gives, incidentally, the fractions of transmitted and reflected light passing at any surface in the system. L.E.T.

X-ray study of streaks in Fourcault window glass. L. A. Afanas'ev and S. V. Rodin. *Keram. & Steklo*, **12** [12] 26–27 (1936).—X-ray pictures show the presence of cristobalite crystals in all glasses studied. The crystal formations are found in the streaks only. The study of X-ray pictures and the results of the chemical analysis of these glasses show that the basic reason for the formation of streaks in window glass manufactured by the Fourcault methods is the inhomogeneity of the glass mass and, as a consequence, its crystallization in the Fourcault channel. M.V.C.

BOOKLETS

Influence of tank on the properties of glass. H. Jebsen-Marwedel. *Fachausschussber.* (Deut. Glastech. Ges.), No. 17, 9 pp. (1929).—The chemical composition, refining, and viscosity of glass are considered. The thermal and chemical activity of the tank atmosphere is all-important. Efficiency and reducing atmosphere are contradictory terms. The problem of sulfate and sulfide reactions is discussed. The effect of (very small) positive or negative pressure is decisive. The working of chambers and the regulation of ports are discussed, and the fundamentals are given concerning interpretation of gas analysis, interaction between glass surface and hot gases, glass gall, distribution of temperatures, glass flows and their erratic alterations, influence of floaters, volatilization of batch constituents, corrosion of blocks, and cordy glass. An appendix on technical literature is included. Illustrated. F.E.V.

Preparation of the charge: II. G. Oppermann. *Fachausschussber.* (Deut. Glastech. Ges.), No. 35, 4 pp. (1935); abstracted in *Chimie & Industrie*, **36** [6] 1169 (1936).—Tests made on mixtures of sand, soda, and lime showed that homogeneity is obtained readily when the moisture of the sand is 5%; above this, the effect of the moisture is injurious. It is preferable to mix the sand and soda first; for glasses rich in silica, dissolving the silica is facilitated by the use of a fine, regular sand, sifted and ground. By "bricking" the charge, it is possible to have the most important stock in a given place, and there will be less loss and a more homogeneous glass. M.V.C.

PATENTS

Adjustable noncircular orifice ring structure for glass

feeders. W. T. BARKER, JR. (Hartford-Empire Co.). U. S. 2,075,756, March 30, 1937 (Jan. 31, 1936).

Apparatus for:

Continuously tempering glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Fr. 798,189 and 798,190, May 11, 1936; *Chem. Abs.*, **30**, 7298 (1936).

Drawing glass. N. V. HOLLANDSCHE MAATSCHAPPIJ VOOR DE VERVAARDIGING VAN GLAS. Ger. 633,399, July 25, 1936; Cl. 32*a*. 23.01; *Chem. Abs.*, **30**, 7808 (1936). OXELÖSUNDS JÄRNVERKS AKTIEBOLAG. Ger. 633,212, July 22, 1936; Cl. 32*a*. 23.01; *ibid.*, p. 7808.

Forming hollow glass articles. A. J. SMITH (Hartford-Empire Co.). U. S. 2,075,363, March 30, 1937 (April 11, 1935).

Introducing glassware into a cooling leer. AKT.-GES. DER GERRESHEIMER GLASHÜTTENWERKE VORM. FERD. HEYE. Ger. 632,140, July 4, 1936; Cl. 32*a*. 34; *Chem. Abs.*, **30**, 6909 (1936).

Making glass building blocks. D. E. GRAY (Corning Glass Works). U. S. 2,075,435, March 30, 1937 (May 21, 1934).

Making glass posts. PETER KUCERA. Ger. 626,605, Feb. 29, 1936; Cl. 32*a*. 5; *Chem. Abs.*, **30**, 5744 (1936).

Making plate glass. SOC. ANON. POUR LES APPLICATIONS DE L'ÉLECTRICITÉ AU VERRE. Swiss 180,518, Feb. 1, 1936; Cl. 113; *Chem. Abs.*, **30**, 8550 (1936).

Making sheet glass. DEUTSCHE TAFELGLAS A.-G. (Detag). Fr. 799,779, June 19, 1936; *Chem. Abs.*, **30**, 8551 (1936). PITTSBURGH PLATE GLASS CO. Ger. 634,124, Aug. 20, 1936; Cl. 32*a*. 19; *ibid.*, p. 8551.

Making tempered glass sheets. PILKINGTON BROS., LTD. Ger. 633,400, July 29, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **30**, 7808 (1936).

Tempering glass. HAROLD PERRY AND AUGUSTUS W. GROTEFELD. Fr. 795,779, March 21, 1936; *Chem. Abs.*, **30**, 5744 (1936). PILKINGTON BROS., LTD. Fr. 800,531, July 7, 1936; *ibid.*, p. 8551. PILKINGTON BROS., LTD., AND W. B. CLITHEROW. Brit. 463,050, April 1, 1937 (Sept. 19, 1935). SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Fr. 800,282, July 1, 1936; *ibid.*, p. 8551. SOC. ASSUREX. Fr. 795,822, March 23, 1936; *ibid.*, p. 5744.

Tempering sheets of glass. RAYMOND MEER. Fr. 797,508, April 28, 1936; *Chem. Abs.*, **30**, 7298 (1936).

Tempering tubular glass objects. PILKINGTON BROS., LTD. Fr. 797,698, May 1, 1936; *Chem. Abs.*, **30**, 7298 (1936).

Casehardening glass. L. V. BLACK (American Securit Co.). Can. 358,847, June 30, 1936; *Chem. Abs.*, **30**, 5744 (1936).—Structural details are described of an apparatus for supporting a glass plate during tempering having a flexible member depending from a pair of supports and engaging the lower part of the plate by its edge and a second flexible member engaging the upper edge portion of the plate.

Casehardening glass. H. J. GALEY (American Securit Co.). Can. 358,848, June 30, 1936; *Chem. Abs.*, **30**, 5744 (1936).—A glass plate is supported in a horizontal position upon a rigid metal grid moved through a heated atmosphere at approximately the softening temperature of the glass, and the grid and plate are moved between fluid cooling means discharging vertically on both sides of the glass.

Colored glass article and method and means for making it. E. C. LEIBIG (Corning Glass Works). U. S. 2,075,446, March 30, 1937 (Oct. 13, 1934). The method of coloring glass red includes heating an alkali-containing borosilicate glass in contact with a copper staining salt until a yellow coloration is produced in the surface of the glass, removing the residual staining salt from the glass, and reheating the glass under reducing conditions until the yellow coloration is changed to red.

Construction of crucible ovens for the glass and other industries. M. H. V. DELOT AND G. A. DELACROIX. Brit. 461,788, March 10, 1937 (May 4, 1936).

Conveying rolled sheets to leer. PILKINGTON BROS., LTD. Ger. 629,149, April 9, 1936 (July 14, 1934); VI/32*a*, Gp. 18; *Jour. Soc. Glass Tech.*, **20** [81] 374A (1936).—The sheet is received from the rolls on a roller conveyer, the rolls of which are driven at the speed of rolling while the conveyer band is driven backwards at a slower speed.

Device for holding glass plates during hardening. PILKINGTON BROS., LTD. Ger. 628,344, April 2, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **30**, 5744 (1936).

Device for holding glass sheets during tempering. HERZOGENRATHER GLASWERKE BICHEROUX & CIE G.M.B.H. Ger. 630,346, May 26, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **30**, 5744 (1936).

Device for protecting the walls of glassmelting furnaces from erosion. BELA SCHWEGER. Ger. 626,799, March 3, 1936; Cl. 32*a*. 1; *Chem. Abs.*, **30**, 5743 (1936). Addition to Fr. 625,578 ("Floaters—," *Ceram. Abs.*, **16** [3] 89 (1937)).

Driving mechanism of glassworking machines. T. F. PEARSON. Brit. 463,322, April 7, 1937 (Sept. 23, 1935).

Electric furnace for fusing glass. SOC. ANON. POUR LES APPLICATIONS DE L'ÉLECTRICITÉ AU VERRE. Fr. 799,363 and 799,364, June 11, 1936; *Chem. Abs.*, **30**, 7807 (1936).

Electric furnace for melting glass. SOC. ANON. POUR LES APPLICATIONS DE L'ÉLECTRICITÉ AU VERRE. Swiss 180,006, Dec. 16, 1935; Cl. 11*a*. Swiss 180,519, Jan. 16, 1936; Cl. 113. *Chem. Abs.*, **30**, 8550 (1936).

Electrically heated annealing leer for glassware. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Ger. 633,213, July 22, 1936; Cl. 32*a*. 29; *Chem. Abs.*, **30**, 7808 (1936).

Eyeglass lens drilling machine. A. T. ROCHTE. U. S. 2,077,266, April 13, 1937 (Aug. 9, 1934).

Feeding molten glass to molds. NEUE GLASINDUSTRIE-GES. G.M.B.H. Ger. 628,234, March 19, 1936 (Aug. 6, 1934); VI/32*a*, Gp. 6; *Jour. Soc. Glass Tech.*, **20** [81] 355A (1936).—The device consists of a trough which diverts the glass stream flowing continuously from a container into the mold or other receptacle without shearing it.

Furnace. J. L. DRAKE (Libbey-Owens-Ford Glass Co.), U. S. 2,077,168, April 13, 1937 (June 19, 1933). E. G. GREEN (Libbey-Owens-Ford Glass Co.), U. S. 2,077,169, April 13, 1937 (July 5, 1934).

Furnace for annealing sheets of glass. COMPAGNIES

RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Fr. 798,807, May 27, 1936; *Chem. Abs.*, **30**, 7808 (1936).

Furnace for melting glass. N. V. HOLLANDSCHE MAATSCHAPPIJ VOOR DE VERVAARDIGING VAN GLAS. Ger. 630,345, May 26, 1936; Cl. 32*a*. 5; *Chem. Abs.*, **30**, 5743 (1936).

Fusing iron electrodes into glass vacuum tubes. JOHANNES NIENHOLD. Ger. 634,236, Aug. 21, 1936; Cl. 21*g*. 13.01; *Chem. Abs.*, **30**, 8551 (1936).—The metal is first coated or superficially alloyed with Si.

Glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Fr. 799,974, June 24, 1936; *Chem. Abs.*, **30**, 8550 (1936).

Glass. I. G. FARBENIND. A.-G. (Waldemar Kaufmann and Everhard Bungartz, inventors). Ger. 633,269, July 23, 1936; Cl. 32*b*. 2; *Chem. Abs.*, **30**, 7807 (1936).—Colorless glass of high transparency to ultra-violet rays and good resistance to water is made from a melt comprising $Ba(PO_3)_2$, preferably with small proportions of free BaO and metasilicate or metaborate of Ba.

Glass-annealing leer. W. A. MORTON (Amco, Inc.). U. S. 2,075,452, March 30, 1937 (Feb. 14, 1935).

Glass basin furnace. VERRERIES DE LA GARE & BELOTTE RÉUNIES. Fr. 796,272, April 3, 1936; *Chem. Abs.*, **30**, 5743 (1936).

Glass closure for metal containers and method of making. R. D. SMITH (Corning Glass Works). U. S. 2,075,477, March 30, 1937 (Feb. 11, 1935). The method of making a glass insert for a metal container includes applying to the periphery of the insert a metallizing composition which contains a flux of the group comprising lead fluoride, barium fluoride, and barium borate, firing the glass insert to incorporate therewith a thin coating of metal extending wholly around the outer edge of the periphery and overlying the opposite faces thereof for about $^1/_{16}$ in., and plating the metal coating with another metal which is easily wet by solder.

Glasses. KODAK, LTD. (Eastman Kodak Co.). Brit. 462,304, March 17, 1937 (Sept. 3, 1935).

Glass-feeding method and apparatus. W. H. HONISS (Hartford-Empire Co.). U. S. 2,077,147 and 2,077,148, April 13, 1937 (Sept. 17, 1932).

Glass-forming machine. W. R. RUCK (Hazel-Atlas Glass Co.). U. S. 2,077,013, April 13, 1937 (Feb. 17, 1936).

Glass furnaces. SOC. ANON. D'ÉTUDES ET DE CONSTRUCTIONS D'APPAREILS MÉCANIQUES POUR LA VERRERIE. Fr. 45,932, Jan. 8, 1936; *Chem. Abs.*, **30**, 5743 (1936). Addition to 776,620 (*Ceram. Abs.*, **14** [10] 247 (1935)). Constructional improvements are discussed.

Glassmaking apparatus. LIBBEY GLASS MFG. CO. Fr. 800,591, July 8, 1936; *Chem. Abs.*, **30**, 8550 (1936).

Glass panes. LOUIS KÄLIN. Swiss 181,989, April 1, 1936; Cl. 11*b*; *Chem. Abs.*, **30**, 8551 (1936). Panes which do not become dimmed by deposition thereon of condensed water-vapor are made by coating a sheet of glass with a Na silicate cement and pressing thereto a second sheet for 2 min. at about 80°.

Glass resistant to alkali-metal vapor. R. H. DALTON (Corning Glass Works). Can. 360,092, Aug. 25, 1936; *Chem. Abs.*, **30**, 7298 (1936). There is applied to the surface of the glass a fused-in layer of an alkaline compound, such as a solution of NaOH, which is thick enough to remain homogeneously attached to the glass.

Glass resistant to alkali-metal vapor. H. P. HOOD (Corning Glass Works). Can. 360,094, Aug. 25, 1936; *Chem. Abs.*, **30**, 7298 (1936). Glass is wet with a 10% solution of NH_4 borate in water, dried uniformly, and heated for about $^1/_2$ hr. to form a layer of B_2O_3 fused to the glass, which is homogeneous, substantially transparent, and not thicker than 0.01 mm.

Glass resistant to alkali-metal vapor. H. P. HOOD AND R. H. DALTON (Corning Glass Works). Can. 360,093, Aug. 25, 1936; *Chem. Abs.*, **30**, 7298 (1936).—The glass is wet with a solution of NaOH and NH_4 borate, dried uniformly, and heated to form a fused-in coating comprising approximately 5 to 10% Na_2O and 95 to 90% B_2O_3 not thicker than 0.01 mm.

Glass-rolling machine. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Ger. 634,123, Aug. 19, 1936; Cl. 32*a*. 18; *Chem. Abs.*, **30**, 8550 (1936).

Glassware. ALFRED HANEY. Ger. 632,338, July 6, 1936; Cl. 32*b*. 8; *Chem. Abs.*, **30**, 6909 (1936). In the manufacture of glassware by molding softened glass under pressure, the materials ordinarily used to ornament the molded articles, *e.g.*, enamels or paints, are applied as a thin layer to the glass before it is molded.

Grooving laminated glass. B. J. DENNISON (Duplate Corp.). Can. 359,725, Aug. 11, 1936; *Chem. Abs.*, **30**, 6910 (1936). The periphery of a reinforced sheet of cellulose acetate lying between a pair of glass sheets in a composite plate is removed by submerging the plate in a bath of H_2SO_4 containing HNO_3 as an oxidizing agent.

Hardening sheet glass. PILKINGTON BROS., LTD. Ger. 633,214, July 22, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **30**, 7808 (1936).

Heat treating sheet glass. HERZOGENRATHER GLASWERKE BICHEROUX G. M. B. H. Ger. 627,219, Feb. 27, 1936 (March 9, 1935); VI/32*a*, Gp. 30; *Jour. Soc. Glass Tech.*, **20** [81] 378A (1936). The nozzles through which the cooling fluid is discharged onto previously heated glass sheets for the purpose of "toughening" are shaped like short Venturi tubes.

Indicating glass level in tank furnaces. V. KLEIN. Ger. 629,744, April 24, 1936 (Feb. 27, 1934); VI/32*a*, Gp. 1; *Jour. Soc. Glass Tech.*, **20** [81] 330A (1936). A line inclined to the horizontal is marked on an inside wall of the tank so that part is below and part above the glass. Other marks above the glass level furnish a means of reading at what distance from the corner of the tank the inclined line meets the glass and so gives an indication of the level of the latter.

Laminated glass. J. W. KAMERER AND E. L. FIX (Duplate Corp.). Can. 359,726, Aug. 11, 1936; *Chem. Abs.*, **30**, 6910 (1936). A sheet of cellulose nitrate plastic is treated in an atmosphere controlled as to moisture content for a period of time to secure a uniform distribution through it of 1.2 to 1.8% of moisture and is secured between glass sheets by gelatin or casein cement.

Laminated glass. A. KAMPFER. Brit. 461,684, March 3, 1937 (Aug. 23, 1935).

Leer stacker. G. E. Rowe (Hartford-Empire Co.). U. S. 2,075,752, March 30, 1937 (Oct. 26, 1934).

Means of withdrawing molten glass from furnaces. Soc. Anon. d'Études et de Constructions d'Appareils Mécaniques pour la Verrerie. Ger. 625,939, Feb. 18, 1936; Cl. 32*a*. 5; *Chem. Abs.*, **30**, 5744 (1936). Addition to 616,444 (*Ceram. Abs.*, **15** [8] 239 (1936)).

Metallized glass surfaces. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey. Fr. 798,550, May 19, 1936; *Chem. Abs.*, **30**, 7298 (1936). The metal or alloy is projected onto glass of low coefficient of expansion, *e.g.*, not above 65×10^{-7}. The glass is heated to 200° to 400° during the projection.

Method and apparatus for abrading lenses. A. H. Stevens (Bausch & Lomb Optical Co.). Brit. 461,774, March 10, 1937 (Feb. 13, 1936).

Method and apparatus for producing glass containers with reëntrant bottoms. L. D. Soubier (Owens-Illinois Glass Co.). U. S. 2,075,771, March 30, 1937 (Aug. 16, 1934).

Method of forming insulating material. A. H. French (A. E. Staley Mfg. Co.). U. S. 2,076,078, April 6, 1937 (April 24, 1935). The method of forming an insulating material comprises mixing an inorganic compound, having substantially no adhesive properties but being fusible at elevated temperatures to form a heat-resisting adhesive, with an organic, easily applied adhesive, incorporating the mixture with rock wool fibers to bind the latter together, and subjecting the fibers to a temperature sufficiently high to fuse the inorganic compound and to burn the organic compound.

Method of heating safety glass assemblies. J. W. Kamerer (Duplate Corp.). U. S. 2,075,726, March 30, 1937 (May 4, 1935).

Method of rendering glass resistant to metal vapors. N. V. Philips' Gloeilampenfabrieken. Brit. 462,440, March 24, 1937 (Aug. 6, 1935).

Milk bottle. J. E. Greenwood (Liberty Glass Co.). U. S. 2,076,124, April 6, 1937 (Dec. 31, 1935).

Multipart glass articles and method of manufacturing. Owens-Illinois Glass Co. Brit. 461,465, March 3, 1937 (May 13, 1935).

Nonsplintering glass. Soc. des Usines Chim. Rhône-Poulenc. Ger. 633,337, July 24, 1936; Cl. 39*b*. 27; *Chem. Abs.*, **30**, 7808 (1936).

Ophthalmic lens. E. D. Tillyer (American Optical Co.). U. S. 2,077,134, April 13, 1937 (April 14, 1934).

Preparation of silica for glass batches. R. Haddan (Corning Glass Works). Brit. 462,213, March 17, 1937 (April 6, 1936).

Process and apparatus for the manufacture of glass articles of tubular shape. F. Meyer. Brit. 461,795, March 10, 1937 (June 8, 1935).

Process for making safety glass. J. H. Sherts (Pittsburgh Plate Glass Co.). U. S. 2,075,667, March 30, 1937 (June 3, 1936).

Production of nonsplintering laminated glass. A. Kampffer. Brit. 462,734, March 24, 1937 (Nov. 13, 1934).

Production of wired glass. R. Geneger. Ger. 629,016, April 2, 1936 (Jan. 22, 1935); VI/32*a*, Gp. 22; *Jour. Soc. Glass Tech.*, **20** [81] 374A (1936). A continuous ribbon of glass produced by rolling is cut up into individual sheets which are then passed through further rolls to produce wired glass, the product being then chilled suddenly.

Reinforced ceramic building construction and method of assembly. F. O. Anderegg. U. S. 2,075,633, March 30, 1937 (May 27, 1936).

Safety glass. I. G. Farbenind. A.-G. Fr. 799,318, June 11, 1936; *Chem. Abs.*, **30**, 7808 (1936).—The resistant layer is made from an ester of high molecular weight of a polyvinyl alcohol by the process of Fr. 792,963 and is applied to the glass by an adhesive. The ester may contain a plastifier or emollient.

Safety glass. Röhm & Haas A.-G. Fr 797,687, May 1, 1936; *Chem. Abs.*, **30**, 7299 (1936).—The intermediate layer is formed wholly or for the greater part of a polymerized mixture or of mixtures of polymerization products of vinyl acetate and butyl acrylate, with or without Me or Et acrylate.

Sheet glass. "Lumière & Clarté" Soc. Anon. Holding. Ger. 634,029, Aug. 14, 1936; Cl. 32*a*. 5; *Chem. Abs.*, **30**, 8550 (1936).—In processes for the continuous manufacture of sheet glass in which an endless strip is withdrawn from a glassmelting tank, the glass, after fusion and clarification in a known manner, is reheated near the point of withdrawal by passing an electric current through it. Fluctuations in the temperature of the glass are thus reduced.

System for hardening glass and like materials by treatment with a gaseous cooling agent. Compagnies Réunies des Glaces et Verres Spéciaux du Nord de la France. Ger. 630,032, May 18, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **30**, 5744 (1936).

System for treating hollow glass articles externally with acids or other liquids. Jan. Anděl. Ger. 632,337, July 6, 1936; Cl. 32*b*. 6; *Chem. Abs.*, **30**, 6909 (1936).

Tank furnace for melting glass. Angermann & Keppler. Ger. 633,488, July 28, 1936; Cl. 32*a*. 5; *Chem. Abs.*, **30**, 7807 (1936).

Tempered glass. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey. Fr. 795,559, March 17, 1936; *Chem. Abs.*, **30**, 5744 (1936).—Glass, particularly for motor-car windows, is tempered so that when shattered it breaks into zones in which the fragments are very numerous and small and into surrounding zones in which the pieces have relatively large dimensions and are of polygonal or circular form. Owing to the presence of the relatively large pieces, the visibility on rupture is not appreciably reduced. The result is attained by producing a more energetic tempering in the first zones.

Tempering glass. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey. Fr. 800,321, July 2, 1936; *Chem. Abs.*, **30**, 8551 (1936).—The sudden cooling is obtained by contact with metal brushes.

Tempering of glass sheets. Pilkington Bros., Ltd., and L. J.-B. Forbes. Brit. 463,051, April 1, 1937 (Sept. 19, 1935).

Tempering sheet glass. L. J.-B. Forbes and John Wilson (Pilkington Brothers, Ltd.). Can. 360,530, Sept. 15, 1936; *Chem. Abs.*, **30**, 7808 (1936).—A glass sheet is cooled by projecting water at a controlled rate in a state

of very fine division against the glass from several uniformly spaced points with reference to each surface of the glass sheet so that the greater proportion of the heat removed from the glass is absorbed by evaporation of the water. An apparatus is described.

Toughening glass sheets. F. ECKERT. Ger. 628,042, March 12, 1936 (Aug. 7, 1933); VI/32*a*, Gp. 30; *Jour. Soc. Glass Tech.*, **20** [81] 378A (1936).—The toughening is carried out by blowing cooling medium onto the sheets, provision being made for applying two or more kinds, one not so drastic as the other. Thus the jets can be arranged in groups to which cooling medium at different temperatures or pressures is supplied.

Structural Clay Products

Brick masonry in State Highway bridges in Ohio. J. C. MERRELL. *Bull. Amer. Ceram. Soc.*, **16** [4] 135–38 (1937).

Brickwork in large buildings. ANON. *Trade & Eng.*, **40** [878] xix (1937).—After experimenting with all kinds of substitutes, the London County Council has definitely adopted the use of brick, considering it to be the most suitable, durable, noninflammable, and cheapest material. It is cheaper than concrete under all comparable conditions. Reinforced brickwork possesses as great a resistance to all forms of stress as reinforced concrete and is preferable where there is much vibration. The beauty of old brickwork is greater than that of old concrete. A.B.S.

Humid aging of fly-ash brick. J. MASON PILCHER AND FRANK C. VILBRANDT. *Ind. Eng. Chem.*, **29** [4] 427–28 (1937).—The essential engineering operations involved in the production of synthetic stone brick are intimate mixing of selected ingredients, compression of the mixed mass at 2500 lb./sq. in. pressure into the required shapes, and induration of this compressed material in an autoclave with steam at about 75 lb./sq. in. gage pressure for 2 hr. Using fly-ash as the fundamental raw material in the production of synthetic brick, the following factors were determined: (1) effect of lower compression conditions, (2) effect of aging the compressed brick in humid atmosphere, and (3) effect of composition when humid aging was substituted for high-pressure induration. Fly-ash brick molded at pressures as low as 1000 lb./sq. in. are stronger than those compressed at 2500 lb. if the former are humid-aged and the latter are atmospheric-aged. Increased time of humid aging results in increased compressive strength of fly-ash brick. Additions of gypsum beyond 1% and rosin in all proportions are deleterious. The humid aging of fly-ash brick when substituted for induration in a pressure autoclave eliminates the necessity for adding rosin which results in brick of lower strength. It also eliminates efflorescence on the brick but does not produce a brick with as high a modulus of rupture as the pressure autoclave brick. F.G.H.

Water absorption of building brick. J. W. MCBURNEY. *Proc. Amer. Soc. Testing Materials*, **36** [Part 1], 260–71 (1936).—The permissible variation in the method of test for absorption from the standpoint of reproducibility of results is determined. M. describes several methods of determining water absorptivity of building brick by 5-hr. boiling methods and records the results obtained by using these methods on 30 specimens, both de-aired and nonde-aired brick. The following conclusions are given: (1) drying for 72 hr. at a temperature of 110° to 511°C in a ventilated oven is sufficient to bring nonde-aired brick of moderate to high water absorption (above 8% by 5-hr. boiling test) to dry weight constant to ± 0.5 g; (2) certain less absorptive brick require 5 days at 110° to 115°C for drying; (3) if the 5-hr. boiling test is made on nonde-aired brick of moderate to high absorption which have been previously immersed in cold water for 48 hr., the total absorption thus measured is, in general, slightly higher than if the 5-hr. boiling test is made on the same brick not previously immersed; (4) some "hard-fired" de-aired brick do not conform in their behavior to conclusion (3), the 5-hr. boiling test giving much higher absorptions when used on dry brick of this type than on the same brick previously immersed cold; the "medium-fired" brick of the same brand conform to conclusion (3); (5) for nonde-aired brick of moderate to high absorption, the difference between the results of 5-hr. boiling followed by thorough forced cooling in 1 hr. and the same test followed by 16-hr. slow cooling is negligible; (6) the higher the temperature of the bath at the time the brick is removed for weighing, the lower is the weight of absorbed water; (7) failure to reach boiling temperature in the bath lowers the amount of water absorbed; (8) the use of incompletely dried specimens results in error unpredictable in size and direction; (9) the 5-hr. boiling test for absorption on sound brick of moderate to high absorption in general is reproducible to within ±0.15%. R.A.H.

PATENTS

Apparatus for molding perforated brick. STANLEY BROS., LTD., AND E. J. ELLIS. Brit. 462,902, April 1, 1937 (Sept. 13, 1935).

Brick, etc., for roads, buildings, and heat-resisting purposes. E. C. STRONG. Brit. 462,484, March 24, 1937 (Nov. 11, 1935).

Manufacture of brick, slabs, etc. C. E. BLYTH. Brit. 461,837, March 10, 1937 (Jan. 8, 1936); addition to 439,332.

Model building brick and method for producing. H. DEDITIUS AND G. V. MENDEL. Brit. 463,108, April 1, 1937 (Nov. 9, 1934).

Sand-faced brick, building slabs, etc. LONDON BRICK CO., LTD., AND F. J. WIGGLE. Brit. 462,836, April 1, 1937 (Oct. 4, 1935).

Refractories

Analyses of Chinese aluminum ores. CHIN-PIN FAN. *Ind. Research* [China], **5**, 179–82 (1936); *Chem. Abs.*, **30**, 7512 (1936).—Analyses of Chinese bauxite and alunite ores are given.

Aluminum and bauxite. C. L. MANTELL. *Mineral Ind.*, **44**, 13–30 (1935).—The leading producers of aluminum in 1935, in order, were Germany, U.S., U.S.S.R., France, Canada, Switzerland, Great Britain, Norway, Italy, Japan, Austria, Sweden, Spain, and Hungary, with a total of 257,000 metric tons. U. S. production was

68,000 tons, 50% being produced at Massena, N. Y. Bauxite production in U.S. was 233,000 tons valued at $1,556,000, the highest since 1930. Georgia and Alabama produced 14,000 tons and Arkansas 219,000. Georgia and Alabama production was used in the chemical industry; Arkansas shipments were for the aluminum, abrasives, chemical, and refractory industries in order. The average price per ton for crude ore was $6.65 for domestic and $4.50 to $6.50 for foreign. Crude ore was imported from British Guiana, Dutch Guiana, and France. Exports of ore and concentrates were principally to Canada and Norway. Estimates for production in foreign countries are given, including Austria, British Guiana, Dutch East Indies, Dutch Guiana, France, Germany, Greece, Hungary, Italy, and Jugoslavia. G.M.P.

Checker brick in open-hearth service. William C. Buell, Jr. *Bull. Amer. Ceram. Soc.*, **16** [4] 139–43 (1937); see also *Ceram. Abs.*, **16** [1] 21 (1937).

Checker brick and regenerators. Raymond E. Birch, *et al.* Discussion at meeting of Refractories Division, American Ceramic Society, Bedford, Pa., Sept., 1936; *Bull. Amer. Ceram. Soc.*, **16** [4] 152–55 (1937).

Heat insulation; selection of suitable materials for various purposes. J. S. F. Gard. *Iron & Coal Trades Rev.*, **134** [3598] 299–300 (1937).—G. discusses the change in temperature gradients in the walls of high-temperature furnaces as affected by the composition of the refractory and heat-insulating materials. Examples show how great economies in material and fuel can be achieved by correct selection of material and correct thickness of the composing materials. The development, which is still in its infancy, of a brick combining both good refractory and heat-insulating properties will be of great importance. M.H.

Influence of material, shape, and size of checker brick on heat transfer in regenerators. J. D. Keller. *Bull. Amer. Ceram. Soc.*, **16** [4] 144–52 (1937).

Improvement in refractory materials for metallurgy. T. Levoz. *Metallurgie*, **68** [13] 11–12 (1936); abstracted in *Chem. Zentr.*, **1937**, **i**, 1506.—Improvements made in the last 50 years in the properties of refractories are described. While in 1885 refractory linings of the composition SiO_2 92, Al_2O_3 6, and Fe_2O_3 1.5% withstood 50 charges, linings of 1929 with a composition of 90 SiO_2, 8 Al_2O_3, and 2% Fe_2O_3 withstood 150 charges. The refractory lining of the composition 81.1 SiO_2, 4.12 Al_2O_3, 8.65 Fe_2O_3, 3.10 FeO, and 1.01% CaO was found satisfactory for melting magnetite at 1800° to 2000°; it resists the attack of slag and metallic oxide well. M.V.C.

Manufacture of dolomitic bottoms of Thomas converters. J. Welter. *Rev. Tech. Luxembourg.*, **29** [1] 1–7 (1937).—The efforts to improve the life of converter bottoms and at the same time to supply the blast under the best possible conditions are reviewed, and several methods are described; an entirely satisfactory solution, however, has not yet been found. One of the latest developments is a bottom built up of short pipes of dolomitic material (Ger. Pat. 524,195, French Pat. 679,719) which has given eight months of unbroken service. The pipes or tubes are slightly conical, 180/185 mm. diameter, and are made under hydraulic pressure of 1000 kg./mm.^{2}; the machine is described. Nine references. M.H.

Problem of inner facing of industrial furnaces. E. S. Greigov. *Argile*, No. 167, pp. 19–25 (1937).—Silica brick are used as lining for furnaces and metallurgical apparatus because of their resistance to high temperatures, high thermal conductivity, and mechanical and chemical resistance; the disadvantage is their expansion which necessitates a special system of construction of joints. The thickness of linings for small furnaces should not exceed 27 cm.; for greater capacity furnaces, 40 cm. Heat-resisting steels are finding favor for recuperators, although they are expensive and deteriorate with long heating, producing rupture. The characteristics of different brick for Cowper recuperators are analyzed. M.V.C.

Obtaining alumina by the Sèailles method. J. C. Sèailles. *Congr. Chim. Ind., 15th Congress, Brussels*, **2**, 894–96 (1935); abstracted in *Chem. Zentr.*, **1936**, **ii**, 1991. M.V.C.

Po-Shan bauxite as a possible raw material for the production of aluminum in China. Shoo-Tze Leo and Wie-Cheng Wei. *Jour. Chem. Eng. China*, **3**, 113–23 (1936); *Chem. Abs.*, **30**, 7720 (1936).—Experiments made on Al_2O_3 made from Po-Shan bauxite show that the purity of Al obtained is closely proportional to the purity of the oxide used, and that the metal obtained in the laboratory experiments is always less pure than that obtained on a commercial scale. The Al produced from Po-Shan bauxite for an estimated commercial scale would satisfy the requirements of British standard specification for aircraft material, 99% Al notched bars and pigs.

Quantitative determination of slag resistance of refractories. S. S. Kozakevich and O. S. Efremova. *Zavodskaya Lab.*, **5** [8] 1011–13 (1936).—Check tests of different methods showed the superiority of the Hartman method. Two samples were tested simultaneously. The permeability to gases proved to be without effect on the slag resistance; higher porosity lowers it considerably. Semiacid samples have little resistance which is highest in graphite samples. The highest slag-resistance was exhibited by silica and corundum masses. P.B. & E.S.

Quenching test for refractories. Simultaneous determination of resistance to abrupt changes of temperature and to corrosion. A. Möser. *Feuerungstechnik*, **24** [2] 20–24 (1936).—To make easier the complicated problem of producing block with good resistance both to temperature change and corrosion, M. sought to develop a method of determination which would permit definite data on the probable behavior to be obtained. For this purpose, the usual methods for the determination of the resistance to temperature changes and the essential property for resistance to corrosion (the permeability) were combined. In this way, it is possible to determine the effect step-by-step of the successive thermal shocks or quenchings in one and the same sample. At the same time, the method is so simple that it can be carried out in any plant. This procedure also offers an improvement over the imperfect method for determining the resistance to temperature change, as not only the final point (as formerly) but also the entire course during the testing for thermal shock is ascertained. Moreover, by changing the method slightly, it is possible to ascertain the classification of the bodies from the kind of destruction and to calculate the amount in percentage of the two main forms

of destruction. With the method indicated, the slightest effect of quenching on the structure can be determined, and the distinction between the different quenching methods can be made clear. See *Ceram. Abs.*, **15** [8] 243 (1936). M.V.C.

Refractories in the last ten years. W. STEGER. *Tonind.-Ztg.*, **60** [104] 1294–95 (1936).—The status and advancement of the refractory industry in the last 10 years are summarily reviewed under captions such as raw materials, preparation and shaping, drying and firing, refractory products, research, and standards. S. predicts further development of new processes: the manufacture of non-oxidizable silicon carbide block, dense insulating block with low heat conductivity figure and low specific heat, basic block with greater resistance to temperature change, and firing under load. M.V.C.

Refractory silica brick. CARLOWITZ. *Feuerungstechnik*, **25** [2] 51–52 (1937).—C. discusses the manufacture of silica brick for coke ovens. M.V.C.

Sillimanite and its use as a super-refractory. ANON. *Corriere Ceram.*, **17** [12] 341–43 (1936).—The monosilicates of alumina are ideal refractory materials for temperatures up to 1800°C. Sillimanite, named after the American, Silliman, has the following formula: $8Al_2O_3 \cdot 9SiO_2$. Since kyanite is transformed into sillimanite above 1370°C, it has been called a calcined kyanite. At 1545°C sillimanite is transformed into mullite, $3Al_2O_3 \cdot 2SiO_2$ (named for the Island of Mull). To facilitate the grinding of kyanite and sillimanite which are harder than mullite, they are calcined into the latter form. Monosilicates of alumina have no agglomerating qualities, but a new process has been found which uses only 10% bond. They have a high mechanical resistance and withstand the reducing or oxidizing action of gas, carbon, and slag. Andalusite, kyanite, and sillimanite are rather rare, but their artificial production is not yet on a practical basis. World deposits are given. M.V.C.

Suspended arches for combustion chambers. ANON. *Indian & Eastern Engr.*, **79** [2] 166–67 (1936).—For a number of years past, standard practice for the combustion chambers of water-tube boilers has included the use of the suspended arch, and this principle is now in extensive use for other furnace settings, especially in the iron, steel, and ceramic industries. An important advance in this field is the Detred arch, a production of M. H. Detrick & Co., Ltd., London. A.P.S.

Thermal conductivity of technical silicon carbide brick. FRITZ HOLLER. *Sprechsaal*, **69** [50] 733–35; [51] 745–47; [52] 761–62 (1936).—The method of Salmang and Frank (*Ceram. Abs.*, **14** [10] 249 (1935)) for measuring thermal conductivity of refractory brick was improved upon and used for determining thermal conductivity of a series of silicon carbide brick. The silicon carbide brick differentiated according to purity of raw materials, varied addition of clay, different firing temperature, varied porosity, and use of different bond. The results of the study show that (*a*) the absolute value of thermal conductivity increases with increased purity of raw materials, (*b*) with increased clay content, thermal conductivity of silicon carbide brick decreases, (*c*) firing of the brick at too high a temperature lowers thermal conductivity because of the disintegration of silicon carbide, (*d*) thermal conductivity decreases with increased porosity, and (*e*) silicon carbide brick with a clay bond of caustic magnesite have a higher absolute value of thermal conductivity than brick with a clay bond. Silicon carbide brick having lower porosity (20%) and a correspondingly higher thermal conductivity were produced. The coarse grain of silicon carbide has a greater specific gravity than powdered silicon carbide. This is due to the fact that fine powder contains a greater percentage of impurities than the coarse grain. M.V.C.

PATENTS

Air-cooled suspended furnace roofs. J. ETWANIK. Brit. 462,446, March 24, 1937 (Nov. 5, 1935).

Brick. SOC. ANON. DES HAUTS-FOURNEAUX DE LA CHIERS. Fr. 799,930, June 23, 1936; *Chem. Abs.*, **30**, 8551–52 (1936). A brick which has the color, look, and hardness of a MgO brick is obtained from calcined CaO by bringing the CaO to a state of fineness of the order of that which corresponds to passage through a sieve of 6000 to 20,000 holes /sq. cm., adding a small amount of oxide of Fe or Cr of the same fineness as the CaO, pressing the mixture to the form of brick with a pressure of 300 to 1000 kg./-sq. cm., and firing at 1350° to 1500° for sufficient time to convert the oxides to Ca ferrite or chromite.

Brick. SOC. ANON. DES HAUTS-FOURNEAUX DE LA CHIERS. Fr. 799,931, June 23, 1936; *Chem. Abs.*, **30**, 8551–52 (1936). Brick are made from fritted dolomite in the same way as in Fr. 799,930. Part of the brick formed may be ground up to the form of grains and added to a fresh charge.

Chrome-ore refractories. F. A. HARVEY AND R. E. BIRCH (Harbison-Walker Refractories Co.). Can. 358,664, June 23, 1936; *Chem. Abs.*, **30**, 5746 (1936). A fired refractory material comprises not less than about 50% chrome ore and about 5 to 50% of olivine. It shows relatively low shrinkage on firing or reheating and is resistant to acids and bases, of low porosity, and cheaply made.

Heat transfer apparatus and refractory wall structure therefor. A. E. NASH (Alcorn Combustion Co.). U. S. 2,075,863, April 6, 1937 (Dec. 19, 1934).

Magnesite brick. MAGNESIT-INDUSTRIE A.-G. Fr. 800,521, July 7, 1936; *Chem. Abs.*, **30**, 8552 (1936). Brick which are resistant to variations of temperature are made by adding Cr ore to the magnesite in the proportion of 10 to 30% of the weight of the brick. Thus, a material may be used containing magnesite in fine powder 0 to 25, Cr ore in fine powder 10 to 20, Cr ore in large grains 0 to 20, and magnesite in large grains 45 to 60% with the addition of a small amount of an organic or inorganic binder. In Fr. 800,522 the Cr ore is used only in large grains so that the fine powder is composed only of magnesite.

Manufacture of chromates. J. B. CARPENTER, JR., AND E. P. STEVENSON (Arthur D. Little, Inc.). U. S. 2,077,096, April 13, 1937 (July 13, 1932). A porous brick comprises a mixture of a suitable carbonate and chrome ore in an amount at least 75% in excess of the theoretical equivalent of the carbonate, the brick being adapted to retain its shape under firing conditions and containing at least 30% of voids.

Method of producing a dolomite brick. JULES ERNOULD (Soc. des Hauts-Fourneaux de la Chiers). U. S.

2,076,884, April 13, 1937 (April 18, 1935). The method of producing a dolomite brick comprises pulverizing dolomite in a dry state, intimately mixing therewith in the dry state a small amount of dry, pulverulent oxide of a metal selected from the iron group, pressing the dry mix, in dry state, under high pressure into desired shape, and then firing the pressed articles, while dry, at a high temperature.

Method of producing a lime brick. JULES ERNOULD (Soc. des Hauts-Fourneaux de la Chiers). U. S. 2,076,883, April 13, 1937 (April 18, 1935). The method of producing a brick of calcined lime comprises pulverizing calcined lime in a dry state, intimately mixing therewith in the dry state a small amount of dry, pulverulent oxide of a metal selected from the iron group, pressing the dry mix, in dry state, under high pressures into desired shape, and then firing the pressed articles, while dry, at a high temperature.

Molded refractory articles. DIDIER-WERKE A.-G. Ger. 630,131, May 20, 1936; Cl. 80*b*. 12.04; *Chem. Abs.*, **30**, 5746 (1936). Addition to 487,110. A granular refractory material, *e.g.*, chamotte, quartzite, or SiC, is mixed with binding clay after the addition of water and an electrolyte capable of converting clay into a slip. A protective colloid may also be added. The mixture is then molded and fired.

Refractories. N. P. PITT, A. C. HALFERDAHL, AND F. E. LATHE. Fr. 796,160, March 31, 1936; *Chem. Abs.*, **30**, 5746 (1936). Refractory materials are made by grinding and intimately mixing calcareous and siliceous substances so as to give a composition which when fired will contain CaO 8 to 76, SiO_2 9 to 40, and Al not more than 5% and will have an effective base-acid ratio of between 1.4 and 3.9 and a hydration value not above 7%, and firing the composition with a stabilizing agent at above 1426°. A large number of examples are given, *e.g.*, dolomite 82.2, chrome ore 6, and sand 11.8% or limestone 65.55, slag 23.55, and sand 10.9% or dolomite 83.7, chrome ore 1, flakes of Fe oxide 3, and sand 12.3%.

Refractory. R. G. LEMMERMAN (Ferro Engineering Co.). Can. 358,528, June 16, 1936; *Chem. Abs.*, **30**, 5746 (1936). A molded refractory is composed, by weight, of SiO_2 sand 11 to 94%, shale burned to provide porosity 5 to 80%, and dry alkali silicate 1 to 9%. The soluble silicate is employed as a binder and is moisture proof to a large degree.

Refractory articles. K. E. BUCK. Brit. 461,960, March 10, 1937 (Aug. 20, 1935).

Refractory bodies and materials and process for making. PILKINGTON BROS., LTD., AND A. R. WOOD. Brit. 463,067, April 1, 1937 (Sept. 21, 1935). Brit. 463,314 and 463,321, April 7, 1937 (Sept. 21, 1935).

Refractory brick or radiants for surface combustion burners. RADIANT HEATING, LTD., AND A. DOCKING. Brit. 462,348, March 17, 1937 (Nov. 27, 1935).

Refractory ceramic objects. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 625,807, Feb. 15, 1936; Cl. 80*b*. 8.19; *Chem. Abs.*, **30**, 5746 (1936). Addition to 607,901 (*Ceram. Abs.*, **14** [9] 222 (1935)). The method of 607,901 for making silicate-like objects from fused glass to which basic constituents have been added and dissolving out the latter by water under pressure is modified by sintering the products at 700° to 1200°.

Refractory composition. E. R. STOWELL. Can. 358,842, June 30, 1936; *Chem. Abs.*, **30**, 5746 (1936). The composition comprises by weight SiC 95 parts, 50 mesh or finer, bentonite about 3 parts, and Na metasilicate 2 parts, mixed to a thick paste with water, placed in a covered container for enough time to permit the bentonite to absorb the silicate solution, and fired.

Refractory lining for furnaces. DYNAMIDO-WERK ENGELHORN & Co. G. M. B. H. Fr. 798,035, May 8, 1936; *Chem. Abs.*, **30**, 7300 (1936).

Refractory magnesite brick. N. A. GOLUSHKO AND F. F. ERNTSBERGER. Russ. 41,423, Jan. 31, 1935; *Chem. Abs.*, **30**, 7300 (1936). A magnesite brick containing bauxite is prepared from coarsely ground magnesite, not over 10 to 25% of grains of which are 0.2 mm. in diameter, while the rest are not under 0.75 mm.

Refractory objects or coatings. ARTHUR SPRENGER. Fr. 800,520, July 7, 1936; *Chem. Abs.*, **30**, 8552–53 (1936). These are made from very refractory materials in grains down to the state of fine powder containing, besides the refractory material, compounds having a lower melting point or materials producing such compounds. The components of the fine material which have a high melting point are composed wholly or essentially of spinels, and the amount of impurities present may be 1 to 15% of the fine material. If the fine material contains 15% of impurities, the proportion of fine material used should not pass 20%, while if it is necessary to use 30% of fine material, the proportion of impurities it contains should not pass 10%. It is advantageous to operate with 40 to 60% of granular material of more than 1 mm. size.

Refractory product. SOC. ANON. DES ÉTABLISSEMENTS A. VALUY. Fr. 798,492, May 18, 1936; *Chem. Abs.*, **30**, 7300 (1936). A mortar for repairing furnaces and making refractory products is composed essentially of fused cement and chromite and, if desired, other basic substances.

Refractory products. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Brit. 462,866, April 1, 1937 (Jan. 17, 1935).

Refractory stone. STEULER-INDUSTRIEWERKE G. M. B. H. Ger. 626,972, March 6, 1936; Cl. 80*b*. 8.15; *Chem. Abs.*, **30**, 5746 (1936). The refractory stone is covered with a protective layer before firing. Thus, chamotte stone is coated with corundum, SiC, Zr, etc., and fired.

Regenerative brickwork. W. M. BAILEY CO. Brit. 461,458, March 3, 1937 (Sept. 27, 1935).

Siliceous brick. HEINRICH KOPPERS' INDUSTRIELLE MAATSCHAPPIJ N. V. Fr. 795,911, March 25, 1936; *Chem. Abs.*, **30**, 5745 (1936). In making siliceous brick poor in or free from clay and which, besides lime, contain other alkaline compounds and other oxides, *e.g.*, of Fe and Mg, the alkali is uniformly distributed in the crude brick and this is maintained throughout manufacture. This is obtained by adding the alkali in the form of caustic alkali, preferably NaOH, and the lime in the form of CaO. An example contains powdered quartz 93, cellulose lye 1, NaOH solution (33%) 3, CaO 2, and powdered Fe oxide 1%.

Soluble silicate binder and method of making and using. N. P. PITT AND A. F. GILL. U. S. 2,077,258, April 13, 1937 (June 26, 1935).

Terra Cotta

Acid-stable brick. RUDOLF RASCH. *Chem.-Ztg.*, **60** [83] 841–43 (1936).—The manufacture of acid-stable brick from clays rich in silica and with a low lime and iron-oxide content is described in detail. Methods suitable for the treatment and working of brick and their range of application are discussed. M.V.C.

Alkali-resistant stoneware. A. VASEL. *Keram. Rundschau*, **43** [37] 433–45 (1935).—To increase the resistance to alkalis, F. Singer advocates additions of MgO, BaO, Cr_2O_3, and SiC and partial substitution of SiO_2 by ZrO_2. V. developed a test method for the determination of alkali resistance of ceramic bodies. The best feldspar content is 20 to 25%; $BaCO_3$, soapstone, and corundum are favorable additions. High porosity has practically no influence. Soapstone decreases stability during firing. F.E.V.

Australian tile for swimming pools. ANON. *Clay Prod. Jour. Australia*, **4** [4] 13 (1937).—A swimming pool constructed of Fowler tile is described and illustrated. H.H.S.

Ceramic linings for chemical equipment. PERCY C. KINGSBURY. *Ind. Eng. Chem.*, **29** [4] 402–405 (1937).—Numerous applications of brick, tile, and chemical stoneware in the field of corrosion-resistant chemical equipment are described. Many types of cement for use in the installation of ceramic linings are discussed. Illustrated. F.G.H.

Manufacture of salt-glazed stoneware pipes and fittings. A. COULHON. *Rev. Matériaux Construction Trav. Publics*, No. 325, pp. 154–57B; No. 326, pp. 172–75B; No. 327, pp. 185–87B (1936); No. 328, pp. 10–13B (1937).—Types of modern furnaces and their construction and operation are described in detail. See *Ceram. Abs.*, **16** [5] 153 (1937). M.V.C.

Pyrophyllite stoneware bodies and their use in the electrotechnical industry. L. V. OMININ. *Keram. & Steklo*, **12** [12] 28–30 (1936).—The composition and manufacture of pyrophyllite bodies containing various admixtures such as clay, magnesia, calcium, lead, talc, etc., are discussed. Clay pyrophyllite bodies are the most plastic; they deform little and are fairly durable. Shrinkage on firing increases with increasing clay content. Their dielectric losses are similar to those of clay talc, but they are superior to the latter in ease of working and firing. Better results were obtained when talc and especially calcium were added. Dielectric losses of bodies containing 15% calcium are $2^1/_2$ times lower; their coefficient of linear expansion decreased from 11×10^{-6} to 3.5×10^{-6}. Additions of CaO and MgO improve the dielectric and thermal properties of pyrophyllite bodies, but their plastic properties are impaired. See *Ceram. Abs.*, **13** [7] 187 (1934). M.V.C.

Scientific manufacture of a ceramic building product: stoneware tile. F. CHALAMEL. *Rev. Matériaux Construction Trav. Publics*, No. 325, pp. 149–51B; No. 326, pp. 169–72B; No. 327, pp. 180–81B (1936); No. 328, pp. 7–10B (1937).—The principal defects of fired products and their cause and remedy are discussed. With the conclusion of the monograph, C. will append six supplements which will go more deeply into the subjects treated. The first will concern a number of clays of different basins. See *Ceram. Abs.*, **16** [2] 66 (1937). M.V.C.

PATENT

Method of manufacture of molds for roofing tile. C. LUDOWICI KOMMANDITGES. AUF AKT. Brit. 462,723, March 24, 1937 (Oct. 1, 1934).

Whiteware

Effect of aging on properties of high-tension porcelain. A. N. EGOROV. *Keram. & Steklo*, **12** [12] 30–33 (1936).—E. found that (1) the working of porcelain insulators from aged mixes is considerably facilitated; and (2) aging does not improve the electrical and mechanical properties of porcelain insulators. M.V.C.

Effect of small additions of bentonite and ball clay to a whiteware mixture. J. W. WHITTEMORE. *Jour. Amer. Ceram. Soc.*, **20** [5] 153–54 (1937).

Pottery in England's industrial history. JOHN THOMAS. *Jour. Roy. Soc. Arts*, **84**, 521–46 (March 27, 1936).—Until recently, the English pottery industry was believed to have been unaffected by the industrial revolution of the 18th Century. Intensive study of records and documents convinced T. that the pottery industry definitely participated in the revolution, owing to the genius of Josiah Wedgwood. In 1782 and 1784, Wedgwood placed successive orders for James Watts' mill and steam engines especially designed for the Wedgwood factories, thus introducing power-driven machinery. Liverpool merchants sent the pottery overseas. The chief order of the century was the Empress Catherine dinner set and tea service of 952 pieces, costing £3000 pounds, sent to St. Petersburg in 1777 and still treasured in the Hermitage Museum, U.S.S.R. Vases, busts, and utility ware in this new steam age went all over the world. A Wedgwood partner became a subscribing member of the Royal Society of Arts, and the elder Wedgwood became a patron of the Society, perpetuating its members in cameos, medallions, and busts. Young artists, modellers, and sculptors, discovered by the Society and encouraged by its premiums, were extensively employed by Josiah Wedgwood in his Etruria plant; among these geniuses were Flaxman and Reynolds. Wedgwood's interest in experiments and in applied science produced ceramic ware of excellent and durable quality and also accumulated a fortune, so that he became in advance a foremost English captain of industry. K.R.

Significance of material tests and of design tests upon electrical insulating materials. L. E. BARRINGER. *Proc. Amer. Soc. Testing Materials*, **36**, 592–99 (1936).—After outlining the purposes of material tests and pointing out their great service in establishing the basic properties of different electrical insulating materials, B. emphasizes the fact that the properties determined in this manner may not carry over unaltered into all design formations that may be contemplated. Sometimes there may be a marked difference between the results of basic tests on laboratory

samples and of performance tests on those same materials after they have been fashioned into the shape required by a particular design. The primary object of this paper is to point out that such differences do exist and to warn the designer to anticipate the possibility of encountering them. That the results of the two types of tests are not always in agreement does not mean that either is inaccurate or useless, but that intelligent consideration should be given to weigh the significance which each may have in any specific design problem. R.A.H.

Syenites in semivitreous ware: II, Plant trials. C. J. KOENIG. *Jour. Amer. Ceram. Soc.*, **20** [5] 148–52 (1937); for Part I see *ibid.*, **19** [10] 295–98 (1936); also in *Ohio State Univ. Eng. Expt. Sta. Bull.*, No. 94, 22 pp. (May, 1937). R.F.R.

Talc porcelain: III, Effect of addition agents on properties of talc-kaolin mixtures. S. KONDO AND S. SUZUKI. *Jour. Soc. Chem. Ind. Japan*, **40** [1] 18B (1937).—The effect of 0.5 to 2% Fe_2O_3, Cr_2O_3, TiO_2, MnO_2, CoO, NiO, CaF_2, and $MgNH_4PO_4$ on the physical properties of talc-kaolin mixtures is given. **IV, Microscopic observations.** *Ibid.*, p. 19B.—Highly talcous bodies containing small proportions of kaolin consist mainly of clinoenstatite and small amounts of mullite, showing sometimes the presence of cristobalite and quartz. In general the structure is rather simple. If the kaolin content is increased, minute crystals of cordierite appear and their ground mass consists of magnesium silicate glasses. Many quartz grains are found in the thin sections of the Siemens steatite porcelain. In the so-called cordierite porcelains, the crystals of cordierite are well developed. Their microstructure is noticeably affected by the addition agents. For Parts I–II see *Ceram. Abs.*, **16** [5] 155 (1937). M.V.C.

Talc in whiteware. R. F. GELLER AND A. S. CREAMER. *Jour. Amer. Ceram. Soc.*, **20** [5] 137–47 (1937).

PATENTS

Devices for fastening tile in a cement foundation. J. BURGEL. Brit. 462,095, March 17, 1937 (March 31, 1936).

Steatite. STEATIT-MAGNESIA A.-G. Fr. 795,437, March 13, 1936; *Chem. Abs.*, **30**, 5745 (1936).—Products in steatite are made from primary materials consisting of Mg silicate and containing Fe, the production of a glaze of different crystalline constitution and color from the interior of the fired mass being avoided by carrying out the firing and cooling in a reducing atmosphere.

Equipment and Apparatus

Bibliography on the use of photoelectric cells in plant investigations. F. M. TURRELL AND LOUIS WALDBAUER. *Proc. Iowa Acad. Sci.*, **42**, 67–70 (1935).—The recent appearance of the "sperrschicht" type of photoelectric cell has made possible the improvement of several old instruments and the development of new ones. These include colorimeters, nephelometers, titration meters, p_H meters, counters, illuminometers, spectrophotometers, reflection meters, and area meters. Recent published work, widely distributed, is brought together by this bibliography for those interested in colorimetric, turbidimetric, and various light measurements. A list of 48 English, 23 German, 2 Italian, and 3 French publications is given. G.M.P.

Capacity of a modern three-phase arc furnace. FRITZ WALTER. *Elektrowärme*, **7** [2] 25–30 (1937).—W. discusses, theoretically, unbalance in the three phases caused by nature of the charge, electrical conditions, and differences in the electrodes. Means to correct the condition by properly arranging the leads to the furnace are discussed. M.H.

Conditioning of insulating materials for test. ROBERT BURNS. *Proc. Amer. Soc. Testing Materials*, **36** [Part II], 600–19 (1936).—B. discusses the problem of air conditioning as applied specifically to the evaluation of raw materials and apparatus to determine whether or not they are suitable for an intended use or to provide the basis of quality maintenance by engineering specifications or both. Air conditioning may be described briefly as being constituted of two general divisions. In the first, scientific and economic bases are developed for illustrating the need for conditioning of specimens for test. Many cases are cited where the lack of control of atmospheric influences results in technical confusion and the needless expenditure of monies. In the second, practical means of controlling the conditioning of test specimens are given. B. gives various ways of producing and maintaining within precise limits those atmospheric influences which are of widest general significance, namely, relative humidity and temperature; in addition reference is made to those conditions, such as light, which have a particularly significant effect on specific materials. R.A.H.

Cone method of determining the absorption by sand. D. O. WOOLF. *Proc. Amer. Soc. Testing Materials*, **36** [Part II], 411–25 (1936).—W. discusses the methods which have been used for determining the absorption by sand, and he indicates the difficulties and errors inherent in these methods. The development of the cone method is briefly stated, and the method is presented in detail. The results of a coöperative series of tests, performed by 12 laboratories, in which the cone method is compared with three other absorption methods, are presented. The conclusion reached is that the cone method is superior to the other methods used and that it furnishes a reliable and accurate result with a minimum of equipment and working time. R.A.H.

Control of fine grind and its theory. J. D. MARY. *Paint Tech.*, **1**, 290, 298 (1936); *Chem. Abs.*, **30**, 6991 (1936).—A formula has been deduced for reducing particle size by fine grinding: $(Sr + St)/V = C$, in which V = the volume (mass, weight, etc.), Sr = sum of the real surfaces produced by grinding, St = sum of the theoretical surfaces, and C = a constant. Fine grinding is regarded as the production of materials which will pass entirely through a 200-mesh sieve with apertures 0.074 mm. sq. Laws relating to the disintegration and division of matter and the theories of Rittinger, Kick, and Stadler are discussed. Kick's law is apparently exact for particles over 155 mm., while Rittinger's law applies to particles below 2 mm.

Effect of departure from planeness of bearing surfaces

on compressive strength of 2-in. mortar cubes. J. R. DWYER. *Proc. Amer. Soc. Testing Materials*, **36** [Part II], 351–56 (1936).—D. studied variations in compressive strength of 2-in. mortar cubes resulting from various departures from planeness in the surfaces of the bearing blocks. Plane, concave, and convex bearing surfaces were included, and the specimens were tested for each of seven bearing conditions and four ages. R.A.H.

Electric welding cast iron. C. D. MCFALLS. *Ind. & Welding*, **10** [3] 17–18 (1937).—M. briefly reviews practical details for successful welding. Low C (0.06% maximum) coated rods are considered the best, C arcs are successful if properly handled, and studded weld is successful; steel electrodes are not practical owing to hardened areas and porosity. Arc weld with a flux-coated electrode in $^1/_8$-in. maximum-diameter size gives low heat effect. Other electrodes are Cu, Monel, and cast Fe. W.H.B.

Equipment and operating data on the Federal Central Heating Plant. J. F. BARKLEY AND C. A. PETERS. *Combustion*, **8** [5] 27–32 (1936).—Operating experiences and performance of the Central Heating Plant which supplies steam to the Triangle Group of new federal buildings in Washington, D. C., are discussed. Test results and a list of the equipment in the plant are included. H.E.S.

Hard facing. ANON. *Oxyacetylene Committee Bull.*, 1935–1936; *Ind. & Welding*, **10** [2] 16–22, 44 (1937).—Details of procedure and materials for application to various ferrous and nonferrous materials are given. General rules, fluxes, and thickness of deposit are discussed. Changes in procedure for steel are based on the C or alloy content and the rolled or cast condition. W.H.B.

Hydrometer method for determining the fineness of Portland-pozzolana cements. S. B. BIDDLE, JR., AND ALEXANDER KLEIN. *Proc. Amer. Soc. Testing Materials*, **36** [Part II], 310–31 (1936).—The determination of fineness of Portland-pozzolana cements involves certain considerations not encountered in the testing of Portland cements because of differences in physical properties of the Portland-cement component and the pozzolanic component of a Portland-pozzolana cement. To supplement the common methods of mechanical analysis of Portland cement and to assist in extending the use of such methods into the field of Portland-pozzolana cement, a hydrometer method of analysis has been adapted from that commonly used in soil analysis. The apparatus is inexpensive and the technique of testing is simple. The method essentially as described herein is being used as one of the acceptance tests for approximately 600,000 barrels of Portland-pozzolana cement for Bonneville Dam. In this paper the theoretical considerations in particle-size determination by the hydrometer are reviewed, the procedure of testing and calculating is described, and typical test results are presented and compared with those obtained by independent methods. The concordance of the test results indicates that the assumptions are reasonable and that the degree of reproducibility is satisfactory for practical purposes. R.A.H.

Internal stability of granular materials. WILLIAM S. HOUSEL. *Proc. Amer. Soc. Testing Materials*, **36** [Part II], 426–68 (1936).—H. discusses inconsistencies which have arisen in internal friction theories and presents the results of a series of tests on five different granular materials. In these data there is no direct relation between shearing resistance, or friction, and the principal pressures which express internal stability in a granular mass. Shearing resistance is measured by direct shear tests and the principal pressures are measured by a specially designed, briefly described, stabilometer test. A general equation for ultimate bearing capacity is derived as well as an equation to represent pressure distribution and capacity at loads less than ultimate. Internal stability is defined. H. concludes that the behavior of granular materials under stress can be accurately and simply described in terms of the stability of elementary arches of soil particles in which the ability to sustain vertical pressure is dependent on the horizontal thrusts supplied by adjacent particles in the mass. R.A.H.

Lining tanks with stainless-clad steel. W. I. KEELOR. *Welding Engr.*, **17** [1] 21–22 (1937).—K. gives details for lining a riveted or butt-welded tank with a 16-gage 18–8 steel sheet by lap welding. W.H.B.

Measurement of high viscosity, a rapid method. R. N. TRAXLER AND H. E. SCHWEYER. *Proc. Amer. Soc. Testing Materials*, **36** [Part II], 518–30 (1936).—The determination of the viscosities of highly viscous materials presents problems and requires methods and apparatus not commonly used in viscometry. Diagrammatic illustrations, directions for operating, and formulas used for calculating the viscosities in absolute units are given for the following types of instruments: (1) the capillary-tube viscometer modified to measure viscosities from 10 poises to 1,000,000 poises, (2) the alternating stress method, by means of which bituminous materials ranging in viscosity from 1,000,000 to 100,000,000 poises have been successfully measured, (3) the rotating concentric cylinder viscometer which may be used to measure a wide range of viscosities, and (4) the falling coaxial cylinder type, which can also be used over a wide range. When considering the development of a rapid, accurate method for control purposes, the last-named type (4) seemed to offer advantages over the others. This instrument has been adapted so that it can be used as a laboratory control viscometer for a very wide range of viscosities. R.A.H.

Metallurgical study of welding. T. SWINDEN. *Welding Ind.*, **4** [12] 427–35 (1937).—Oxygen in the weld deposit is dependent on the electrode coating. Quench aging results indicate that the C content has the controlling effect. Thorough deoxidation is required for high impact (nonaging), but this also produces small grain size. Which of the two, grain size or deoxidation, is responsible has not been determined. Strain-age embrittlement is discussed with data from the literature. Cracking and stresses are shown to be related possibly to the Mn, Si, and S content of the weld metal. Dilation on freezing of the deposit is considered as to its effect on cracking, and data from the Steel Castings Research Committee are presented and discussed relative to the phase of the problem. Fatigue tests appear to be most useful in determining quality of the weld; limiting fatigue stress of weld metal is of little value, and full-scale fatigue test on typical welded joints is best. W.H.B.

Modern grinding system for hard materials. ANON.

Danish Foreign Office Jour., No. 187, 92–95 (Aug., 1936).—Remarkable efficiency is claimed for the Unidan mill, made by F. L. Smidth & Co., Copenhagen. The same firm claims to have constructed the world's largest rotary cement kiln, which is now operating in Denmark. The evolution of grinding mills is traced, the improvements effected are outlined, and the manufacture of the Unidan mill is described with photographs. H.H.S.

Nondestructive tests. E. A. ROLLASON. *Welder*, **9** [38] 6–11, 25 (1937).—R. reviews tests applied to welded structures, including pressure, magnetic (oscillograph type developed by Bureau of Standards), magnetic dust, weld meter (to test formation of magnetic poles), electrical, acoustic, ultra-sound (supersonic), X-ray radiography and spectroscopy, and gamma-radiography tests. The methods are briefly described and some are evaluated from the literature. The X-ray spectroscopy method is recommended for use as a research tool to indicate the grain size, orientation of internal stress, recrystallization of the weld, and transition zones of a weld cross-section. W.H.B.

Nonmetallics. OLIVER C. RALSTON. *Eng. Mining Jour.*, **138** [2] 93–96 (1937).—R. discusses the uses of froth flotation, tabling, and agglomeration in the recovery and separation of nonmetallics such as clays, feldspars, etc. Magnetic separation, electrostatic separation, and fine grinding and shredding devices are mentioned. 3 photomicrographs. J.L.G.

Pipe line that travels. ANON. *Factory Management & Maintenance*, **95** [1] 60–61 (1937).—The construction and operation of the Johns conveyer is described. This conveyer consists of two interlocking rubber belts, each reinforced by a heavy chain embedded in the rubber. The halves fit together at the edges by means of double tongues and grooves to form a closed pipe which will not allow the material carried to sift or leak out. Either solids or liquids can be transported vertically or horizontally. The belt is designed to load while passing under or through a hopper. Disklike partitions prevent slipping or packing of the material on vertical lifts. Twisting the tube seals the halves. Illustrated. J.L.G.

Pulverizing in cement manufacture. R. M. HARDGROVE. *Concrete* [Cement Mill Ed.], **43** [5] 40–41 (1935).—An airswept pulverizer of the ball-bearing type is described. It is suitable for use in the direct firing of kilns, which is advantageous, because it (*a*) has lower first cost, (*b*) eliminates a separate pulverizer, (*c*) reduces labor cost, and (*d*) eliminates dust nuisance. Several installations are described. In some plants the pulverizer has been used interchangeably on coal, clinker, and raw material. W.D.F.

Recent advances in autoclaves. V. A. YARDLEY. *Chem. Age*, **32**, 570–71 (1935).—Great advancement in the manufacture of alloy steels has made possible construction of autoclaves to meet increasingly severe temperature, pressure, and corrosion requirements in industry. Vanadium, chromium, manganese, cobalt, nickel, molybdenum, tungsten, and silicon have been found most useful for alloying. The most valuable steels are the low-alloyed nickel-chromes, with small contents of other elements, possessing a wide range of mechanical properties and having an approximate analysis of carbon 0.3, silicon 0.2, manganese 0.6, phosphorus and sulfur 0.03, nickel 2.5, chromium 0.6, and molybdenum 0.6%, with iron the remainder. Y. describes, in a concise, complete form, various types of autoclaves designed particularly to achieve some definite result such as purity of product and satisfactory performance in the presence of certain materials. Methods to determine the size and wall thickness of vessels are given. M.J.H.

Selection of correct valve types and sizes for automatic flow-control applications. E. S. SMITH, JR. *Instruments*, **10** [3] 75–82 (1937).—S. discusses gravity flow in a short pipe, gravity flow in a long horizontal line, boiler feed with a centrifugal pump, and streamline first-power (viscous) flow. R.W.R.

Size distribution of ceramic powders as determined by a particle-size air analyzer. P. S. ROLLER. *Jour. Amer. Ceram. Soc.*, **20** [5] 167–74 (1937).

Theory of the washing of minerals. WITOLD BUDRYK. *Congr. Internat. Mines Metal. Geol. Appl., 7e Session, Paris, Oct., 1935, Mines*, **1**, 208–18; *Chem. Abs.*, **30**, 6991 (1936).—A new theoretical formula is deduced, giving the rate of fall of a solid in a fluid (gaseous or liquid) medium, that coincides with the formulas of Stokes and of Rittinger, within the limits of their field of application. This formula gives results that agree with experience within the range where neither of the other two is applicable and for which only empirical relationships had hitherto been indicated. The loss in weight of the mineral produced by a fluid varies according to whether the fluid is stationary or moving; the same fluid, according to the condition of its movement, can behave (as to its buoyant effect) as though it were very light or very heavy, or even as though it had a "negative" density. This peculiar phenomenon was not taken into consideration in the present theories of washing. The intervention of this factor permits the results obtained in practice to be brought into agreement with those of theory, contributes to the elucidation of the phenomena which take place during washing or pneumatic purification, and gives indications as to the conditions or regulation of equipment that permit of either eliminating or considerably increasing preliminary classification.

Use of hard metal tools in the chemical industry. KARL BECKER. *Chem. App.*, **24** [3] 33–35 (1937).—Hard metals made in Germany for the special use of working metals and vitreous and clay products are reviewed. In general, three groups are distinguished: (1) widia XX, titanite U, and böhlerite E, for materials giving long chips, are used for steels of different degrees of hardness; (2) widia N, titanite G, and böhlerite GS, for materials giving short chips, are used for cast Fe up to 250 Brinell hardness, Cu and Cu alloys, light metals, marble, and hard rubber; and (3) widia H, titanite GG, and böhlerite HG, for very hard materials with very short chips, are used for hard castings, malleable castings, granite, porcelain, and glass. All materials are made of sintered alloys consisting mainly of tungsten carbide, sometimes with additions of Co and titanium carbide. A collection of tools is illustrated. Four references. M.H.

Wear of iron alloys on mineral materials. E. KNIPP. *Giesserei*, **24** [2] 25–28 (1937).—Steels with up to 0.5% C showed that with increasing C wear reduces considerably while Mn has the same but not as pronounced an effect.

Mo does not increase wear resistance up to 1% but rather reduces it independent of the C and Mn content of the steel. In general, it was agreed that there exists no relation between Brinell hardness and wearability just as there is none between hardness and chippability. M.H.

BULLETIN

Grinding in ball mills with special reference to batch mill grinding. MAGNE MORTENSON. *Kgl. Norske Videnskab. Selskabs, Skrifter 1935,* **II,** No. 36, 16 pp. (1936); *Chem. Abs.*, **30**, 7392 (1936).—Experiments were carried out in a small wet mill with sifted quartz. After a specified time of grinding, the product was analyzed by means of sieves. Grinding below a given size required such a considerable increase in work that the grain size of the original product is of little importance as to the total time. In grinding between 2.5 and 0.12 mm., the surface produced is proportional to the total time. A maximum effect was obtained on increasing the ball charge. Best grinding was obtained with a small ore charge, but the amount of water had little effect. Best grinding was obtained with the mill running at critical speed. The relative time for the same degree of fine grinding was soapstone 22, iron ore 43 to 48, pyrites 48 to 74, and milk quartz 100.

PATENTS

Apparatus for drying and heating stone, slag, and other materials. W. SANGWIN. Brit. 463,246, April 7, 1937 (Sept. 21, 1935).

Apparatus for measuring, recording, and controlling dilute dust concentrations. PHILIP DRINKER AND W. G. HAZARD. U. S. 2,076,553, April 13, 1937 (March 5, 1934). U. S. 2,076,554, April 13, 1937 (Jan. 21, 1932).

Apparatus for separating solids from liquids. F. A. SMITH [illegible] O. C. STERN. Brit. 461,457, March 3, 1937 (Jan. 21, 1936).

Brick grab. J. P. MARTIN. U. S. 2,076,204, April 6, 1937 (April 14, 1936).

End liners for grinding mills. AMERICAN BALL-MILL CO. Brit. 461,726, March 10, 1937 (Sept. 9, 1935).

Furnace wall, etc. R. C. BENNER AND G. J. EASTER (Carborundum Co.). U. S. 2,075,694, March 30, 1937 (May 31, 1934).

Grading machine. H. P. DAWES AND H. R. POWER (Carborundum Co.). U. S. 2,075,097, March 30, 1937 (Aug. 25, 1932). A screen for the separation of granular material comprises a frame having light sides and ends and a relatively larger base, a groove in the base, means for locking fabric in the frame comprising a cord which retains the outer portions of the fabric in the groove, and bumpers on the ends of the frame for distributing jars to the material being separated by the screen.

Method and means for testing. E. O. RHODES (Koppers Co.). U. S. 2,076,592, April 13, 1937 (Oct. 23, 1935). In apparatus for testing the stability of plastic and semi-plastic materials and mixtures, the apparatus includes a mold adapted to receive a test specimen, the mold being provided with an outlet orifice and a plunger orifice, a plunger movable into the mold and in alignment with the outlet orifice, means for actuating the plunger to load the test specimen, and means for indicating the resistance developed in forcing a portion of the test specimen through the outlet orifice, the surface area of the face of the plunger in contact with the surface of the test specimen being slightly less than or substantially the same as the area of the outlet orifice but not as great as the area of the face of the specimen acted on by the plunger.

Production of compact molded bodies from ceramic masses, concrete, etc. ELISABETH LUX AND JOSEPH DANIELS. U. S. 2,075,992, April 6, 1937 (Aug. 30, 1934).

Kilns, Furnaces, Fuels, and Combustion

Blue-smoked brick. ARTHUR MEIER. *Tonind.-Ztg.*, **61** [6] 61–62 (1937).—Practical instructions for firing and smoking the brick and cooling the kiln to obtain blue-smoked brick of good quality are given. M.V.C.

Chamber furnaces in Czechoslovakia. E. RAMMLER. *Feuerungstechnik*, **25** [1] 7–14 (1937).—Details of the construction and operation of chamber furnaces and results obtained are discussed. M.V.C.

Continuous ovens in fine ceramics. J. GREWE. *Keram. Rundschau*, **43** [23] 264–66 (1935).—If properly handled, continuous ovens will not deteriorate the glazes of fine ceramic bodies. Their economic superiority makes it necessary to study their adaptability in each case. G. describes the four-box type, the box-ring oven with direct firing, and the same with conical boxes. These kilns may be used with or without muffles. The method of working and the distribution of time are indicated. Secondary air admission is important. During volatilization of salt glazes, waste gas must be evacuated directly. Illustrated. F.E.V.

Cracks in roof tile from firing and cooling. P. THOR. *Tonind.-Ztg.*, **61** [5] 53–54 (1937).—The temperature of the flue gas in its passage over the ware to the chimney falls below its dew point, and some of the moisture content condenses on the tile, causes tensions, and with further smoking, cracks. If the hot brick come in contact too suddenly with the cooling air, cracks are also formed. M.V.C.

Faults in firing brick. J. JANASZEWSKI. *Tonind.-Ztg.*, **60** [102] 1257–60 (1936).—The commonest mistakes in firing brick are (1) irregular, uneven, and retarded firing in the bottom of the furnace, (2) irregular and insufficient fire, and (3) waste of fuel. Correction in the first case can be contemplated to any extent only in new or remodeled plants, while in the last two cases it may be achieved more or less satisfactorily. M.V.C.

Firing refractory brick. R. KLESPER. *Feuerungstechnik*, **24** [12] 214–19 (1936).—The firing of silica brick in gas chambers with overhead flame is described in detail. Directions for firing and difficulties encountered are enumerated. Illustrated. See *Ceram. Abs.*, **16** [3] 91 (1937). M.V.C.

Furnace atmosphere. GUSTAV NEUMANN. *Arch. Eisenhüttenwesen*, **10** [7] 1–12 (1937).—The question of establishing artificial atmosphere suitable for the heat treatment of products is discussed in detail with special

study of the steel industry. Examples from practice are given. The production and use of outside protection and reaction gases of the composition chosen for the heat treatment and their introduction into the furnace are discussed. The chemical and refractories industries use similar plants for the production of similar reaction gases. M.V.C.

Fusibility of coal ash. J. J. BRENNAN, D. F. MITCHELL, F. P. TIERNEY, AND W. C. THOMPSON. *Ind. Eng. Chem., Anal. Ed.*, **9** [3] 106–11 (1937).—The fusibility of coal ash and its relation to clinker formation are studied by means of the De Graaf electric fusing method. Illustrated. F.G.H.

Hydrogenation tests on Canadian coal. T. E. WARREN AND R. E. GILMORE. *Ind. Eng. Chem.*, **29** [3] 353–58 (1937).—The results of hydrogenation tests on a typical bituminous coal from eastern Canada are given together with a description of the equipment and method developed at the Fuel Research Laboratories of the Department of Mines for such tests. Illustrated. F.G.H.

Mathematical determination of the composition of generator gas. RUDOLF CZERNY. *Feuerungstechnik*, **24** [12] 207–10 (1936).—Processes occurring during gasification and the dependence of CO and H_2 on the CO_2 content and temperature are discussed. The gasification temperatures are calculated, and the effect of moisture on the composition of gas and its heating value is dealt with. M.V.C.

Method of reducing heat losses from furnace parts. A. E. BADGER. *Glass Ind.*, **18** [3] 83–84 (1937).—To determine whether metallic sheets would be useful for insulating some parts of high-temperature industrial furnaces, a section of the side wall in the working end of a large glass tank was chosen for the test. As Corhart refractory blocks were used in this furnace, thermal conductivity data were available. Two sets of tests were made, one in which aluminum sheet was used with a $\frac{1}{2}$-in. separating air space, and one in which aluminum paint was applied directly to the surface of the block. The method of test was to measure the surface temperature of the refractory by means of two thermocouples which were attached to the surface of the test panel near the mid-area. Surface temperatures were measured both before and after applying the insulating material. From these measurements and thermal conductivity data, the heat saving by insulation was computed. The use of sheet aluminum decreased heat loss about 49%, while the use of aluminum paint decreased heat loss about 8%. E.J.V.

Specially constructed electric furnaces for a branch of the heavy ceramic industry. M. H. G. NYSSEN. *Congr. Internat. Applications Électrocalorif. Électrochim., Scheveningen, June, 1936*, Advance copy, D, 15 pp.; *Chem. Abs.*, **30** [22] 8545 (1936).—The development of the application of electric furnaces for a part of the ceramic industry in the province of Limburg (Holland), especially for glazing brick and roofing tile, is described. The rentability of these furnaces is shown by calculations, and cases are indicated in which they surpass the coal furnaces ordinarily used.

Studies in coal problem by X-ray diffraction methods. C. MAHADEVAN. *Quart. Jour. Geol. Mining & Met. Soc. India*, **7** [1] 1–24 (1935).—The source of X-rays was a Shearer tube with water-cooled aluminum cathode and copper target. The X-ray beam was passed through a lead tube containing a series of three small holes varying from 0.75 mm. to 2 mm. in diameter, thus preventing diffraction by the metallic edges of the holes from reaching the photographic plate. The vitrain pattern indicates that the particles are of a colloidal nature and that carbonaceous matter of vitrain contains the hexagonal carbon rings having the same structure as in graphite. The durain pattern consists of the superposition of ash and graphitic carbon spacings on the vitrain pattern. The fusain pattern indicates the presence of a fibrous structure, in addition to ash and free carbon, and a lower percentage of moisture and volatile matter. Comparing results with proximate analysis of the coals, the scattering index of the X-ray patterns compares with the sum of the moisture content and volatile matter rather than with either of them individually, pointing to their close association. The X-ray patterns of dehydrated and devolatilized coals suggest that the general scattering in the haloes in coal patterns is due to volatile matter and moisture content, and that there is a stable-structure nucleus, *i.e.*, the hexagonal graphite carbon ring. Alpha and beta extractions from coals were found to be nearly identical. Gamma compound gave an X-ray pattern similar to that for resins but much more complex. The ash in vitrain is colloidal and in durain partly colloidal and partly in coarse suspension; in fusain most of it is coarse. Most of the mineral matter is silica and alumina. A.P.S.

Tennessee coals, their classification and analyses. P. B. PLACE. *Combustion*, **8** [3] 37–41 (1936).—The individual coal seams of the state are traced through various counties, the coals are identified by county and trade names, and their characteristics and analyses are given. Knowing the source of a Tennessee coal and its moisture and ash content, a complete analysis may be set up from the values given in the tables which will be sufficiently accurate for most power plant purposes. H.E.S.

Thermodynamic and technical bases of chamber firing. R. FEHLING. *Feuerungstechnik*, **25** [1] 1–7 (1937).—Principles of operation and construction of chamber furnaces are discussed. M.V.C.

PATENTS

Electrically heated kiln for ceramic ware. PORZELLANFABRIK LANGENTHAL A.-G. Swiss 181,755, March 16, 1936; Cl. 8*c*; *Chem. Abs.*, **30**, 8551 (1936).

Gas-fired kilns. BONNYBRIDGE SILICA & FIRECLAY CO., LTD., AND W. MCBRYDE. Brit. 462,606, March 24, 1937 (Sept. 13, 1935).

Tunnel furnace for ceramic products. LA TECHNOTHERMIE. Fr. 46,287, April 8, 1936; *Chem. Abs.*, **30**, 7300 (1936). Addition to Fr. 775,201.

Tunnel furnace for firing porcelain. KERAMISCHE INDUSTRIE BEDARFS A.-G. Fr. 797,689, May 1, 1936; *Chem. Abs.*, **30**, 7300 (1936).

Tunnel kilns. F. M. HARTFORD. Brit. 461,810, March 10, 1937 (June 20, 1935).

Geology

Bauxite in Gold Coast, Africa. W. G. G. COOPER. *Bull. Imp. Inst.*, **34** [3] 331–47 (1936).—The total estimated quantity of bauxite in four groups of deposits is 226 million tons. H.H.S.

Bauxite: world sources. E. C. HARDER. *Trade & Eng.*, **40** [877] iii (1937).—The bauxite requirements for the U. S. A. and Canada are chiefly obtained from Dutch Guiana, that for the U. S. A. being shipped to New Orleans and Mobile on the Gulf of Mexico and thence by rail; some bauxite is obtained from Arkansas. Bauxite for Canada is shipped to the St. Lawrence and up the Saguenay River to Port Alfred. Bauxite for the United Kingdom and Norway is chiefly shipped from southern France, but some is obtained from the Istrian Peninsula, Italy. There is a little bauxite in Ireland. Germany has no bauxite deposits and obtains its supply from Hungary, the Dalmatian coast, France, Italy, Yugoslavia, and, recently, the Dutch East Indies and Greece. The Russian bauxite is of low quality; it occurs chiefly at Tikhvin, east of Leningrad. Japanese bauxite is chiefly derived from Korean alunite. Extensive, undeveloped deposits occur in Rumania, Brazil, tropical Africa, and British India. The greater part of European bauxite contains more than 20% iron oxide, while that in the Guiana region contains less than 2%. The bauxite of British India contains 10 to 12% of titania, and that in the Dutch East Indies 1 to 12%. Bauxite from other sources contains an intermediate proportion. Because European bauxite does not contain so much free moisture as that in North and South America, it is not dried before shipment. In Europe, the bauxite is won chiefly by mining, but in America it is won by open pits. **France's varied activities.** H. D'AUVIGNY. *Ibid.*, p. xii.—Bauxite abounds in the south of France. Little is won from the ruined town of Baux where it was first found, the chief sources now being in Bouches-du-Rhône, Var, Hérault, and Ariège. About one-third of the world's output is obtained from France, *i.e.*, 500,000 tons. It is converted into alumina in works at Gardanne and La Barasse near Marseilles, St. Auban in the Lower Alps, and at Salindres, near Nimes. **Hungary.** BARON WEISS. *Ibid.*, p. xix.—The Hungarian bauxite deposits discovered after the War are situated in the Vértes Mountains near the village of Gánt, and in the Bakony Mountains near Tapolcza and Halimba. The mines were opened in 1926 and in 1936 produced 366,505 tons (about one-fifth of the world's output). **Spain.** ANON. *Ibid.*, p. xix.—Several deposits of bauxite in Spain form an extension of those in southern France, but the ore is too siliceous to be of much value, and the demands of the Spanish market do not justify the erection of a works. **Austria.** *Ibid.*, p. xxiv.—The Austrian deposits of bauxite are of no economic value. The deposits between Gmain and Glenegg in the Untersberg Mountains have never constituted an important source of supply. Smaller deposits at Dreistaetten, Piesting, south of Vienna, Hoellgraben near Heiflau in Northern Styria, Laussa near Windisch-Garsten, and near Salzburg are of geological interest only. **Soviet Russia.** *Ibid.*, p. xxxvii.—Large deposits (9,000,000 tons) of bauxite occur in 18 localities on the eastern slopes of the Ural Mountains. These deposits contain only 44% of alumina and an excess (12 to 15%) of silica. **Japan.** *Ibid.*, p. xxxvii.—There is a serious lack of bauxite in Japan, but the Mitsui Mining Co. is interested in bauxite deposits in the Caroline Islands. From Bintang in Dutch East Indies bauxite is being imported into Formosa. **Italy.** *Ibid.*, p. xxxviii.—Deposits of bauxite of good quality existed within the old frontiers of Abruzzi and Apulia. Others have recently been found in Campania and in Gorizia. By the annexation of Istria, vast deposits of bauxite were added to Italy. The present output of bauxite is 31,000,000 tons. A.B.S.

Beryl deposits of Ajmer-Merwara. K. L. BHOLA. *Trans. Mining & Geol. Inst. India*, **29** [2] 127–39 (1934).—The beryl-bearing pegmatites are intruded into Archean rocks, generally mica schists and amphibolites. There is a definite zonal arrangement of the pegmatite constituents: a core of massive quartz, surrounded by coarse feldspar with books of mica, and graphic quartz and feldspar with all the ferromagnesians at the border. Beryl occurs more particularly with the coarser textured and albite-rich pegmatites; it always occurs at the contact of quartz and feldspar, generally in the latter. In one pegmatite a single crystal yielded 15 tons of beryl. The deposits could not be worked economically unless accompanied by mica or marketable forms of quartz and feldspar. A.P.S.

Bleaching clay: I. RAFAEL FUSSTEIG. *Petroleum Engr.*, **8** [5] 98 (1937).—F. discusses the origin and composition of bleaching clays. Physical structure is of far greater importance than chemical analysis in determining the adsorptive power of a clay. Bleaching clays may be divided into three types: (1) Fuller's earth with the developed montmorillonite structure, the microscopic channels being partly filled with other silicates. The action of weak acid leaches the remainder of these inhibitors. (2) Inactive bleaching clay, such as bentonite with the developed montmorillonite structure, the microscopic channels being entirely filled with other silicates. In this instance, a leaching process must be carried out by means of strong acid. (3) Bauxite, whose exterior surface causes a desulfurization and decoloration of oils. Since a water content weakens the sphere of action, a calcination at a temperature of 400° to 600°C must be carried out. Exceeding this temperature destroys the desulfurization power. **II.** *Ibid.*, [6] 64.—F. discusses the theory of adsorption of impurities from oils by clay. R.F.R.

Characteristics of palygorskites. H. LONGCHAMBON. *Compt. Rend.*, **204** [1] 55–58 (1937).—Examination of a great number of specimens showed the mineral to have properties analogous to sepiolites from which the palygorskites very likely are derived by isomorphous replacement of the Mg by Al. M.H.

Comparative investigations of "clay substance" in kaolins, clays, and soils, with especial consideration of the Kallauner-Matějka method. A. ABEL AND K. UTESCHER. *Z. Pflanzenernähr., Düngung & Bodenkunde*, **42**, 277–303 (1936).—Kaolin, clay, and soils are entirely different disintegration products of the same definitely known minerals. Mechanical, chemical, and climatic influences have occasioned these differences. Accordingly, the same fundamental research methods are applicable to

all three in determining their origin, composition, and properties or their technical value and their usefulness in land or forest improvement. The authors limit their inquiries to evidences of weathering. They tested 23 kinds of clay and soils, utilizing methods long in vogue, and they reviewed the literature of 30 authors. In every case they give results of the Kallauner-Matějka method, which states that the kaolinite molecule decomposes under heat, becoming soluble in HCl. The so-called rational or sulfuric acid method has long been important in the ceramic industries and, in a somewhat changed form, in current laboratory practice. In the porcelain and stoneware industries it has been used to determine the mineral composition of kaolin and pure clay and to ascertain a clay content resembling quartz and feldspar. The research methods and results are not only given *in extenso* but are condensed into 8 pages of tables, reference, and interpretation. Conclusions are as follows: (1) For pure kaolin, the Kallauner-Matějka method gives practically the same results as those of the Prussian Geological Survey; the method is cheaper and takes less time. It attacks the plagioclase (feldspar) more powerfully; the sulfuric acid method attacks the orthoclase (potash feldspar). In exact comparison of details, the Kallauner-Matějka method appears more certain than the other method. (2) For crude kaolin and kaolinized clays both chemical and optical research are required, their composition being complicated and their several components varying in content. Good results in this group are obtained on combining the sulfuric acid and the Kallauner-Matějka methods. (3) For products of clayey weathering the latter method is advisable. Held at 700° for 3 hr. these unstable silicates undergo decomposition; as they occur incrusted, they are more resistant to attack by acids, their glassy masses being imbedded in soil particles. (4) Application of the Kallauner-Matějka method to disintegration products has clearly defined characteristic differences between "kaolin" and "clay." Results of the present investigations are intelligible on the principle that kaolin and clay originate under quite different conditions and on chemical disintegration are fundamentally different substances. This does not prevent their occurring side by side or, under certain atmospheric conditions, interpenetrating one another. A merely gradual differentiation is deceptive. (5) The use of optical research is as desirable for soils and clays as for pure kaolin and is of the highest value. In the nature of the case, the greatest difficulties will be encountered, and while the optical method supplements the chemical, it can not entirely supplant it, especially for quantitative evaluation. K.R.

Cryolite, its extraction and use. ANON. *Danish Foreign Office Jour.*, No. 187, pp. 87–91 (Aug., 1936).—The only place in the world where cryolite is found in any quantity is Ivigtut, Greenland. Occurrences elsewhere, small and impure, are at Pikes Peak, Colo., and Miask in the Urals. The annual output from Greenland is 25,000 tons, of which one-third goes to the Pennsylvania Salt Co. for distribution in America, and two-thirds to Oresunds Chemiske Fabriker, Copenhagen, which supplies the rest of the world, the Danish export being valued at 10 million kroner. The enamel industry takes 30% of the cryolite output, the glass industry 10%, and the aluminum industry nearly 60%. Recently, cryolite with a high F content (44%) has been sold as insecticide under the name of Cryocid. The processes of extraction and refining are described. Illustrated. H.H.S.

Danish flint pebbles. ANON. *Danish Foreign Office Jour.*, No. 187, pp. 95–96 (Aug., 1936).—The flint deposits of Denmark are owned by Danish Flint Export (Scheitel & Co.), Copenhagen. The commercial products are flint pebbles for milling, boulder flint as a raw material, and crushed flint for artificial grinding stones, flint paper, and sandblasting. H.H.S.

Development of quartz porphyroblasts in a siliceous hornfels. G. E. GOODSPEED. *Amer. Mineralogist*, **22** [2] 133–38 (1937).—A siliceous hornfels in the Wallowa mountains of northeastern Oregon contains small quartz porphyroblasts. In this section, the porphyroblasts show several stages of development from the initial forms, which are barely distinguishable from the groundmass because of the abundance of minute inclusions, to later forms which are gradually cleared of inclusions. Some of the porphyroblasts have euhedral boundaries yet consist of several individuals of varying orientation. Idiomorphic pyrite is contained in some of the quartz porphyroblasts. The petrographic evidence seems to indicate a facility of crystallization in environment which might not be expected to favor idiomorphism and may indicate an initial step in the recrystallization of the rock. F.J.Z.

Disperse structures: III, Structures of the higher order of silicium dispersoids. V. S. VESELOVSKIĬ. *Zhur. Fiz. Khim.*, **7** [6] 911–17 (1936).—The high-order structures of chalcedony have been investigated. See "X-ray—," *Ceram. Abs.*, **14** [9] 221 (1935). P.B. & E.S.

Feldspars in the amygdaloids in the Lingadhalli traps, Kadur district, Mysore. CHARLES S. PICHAMUTHU. *Quart. Jour. Geol. Mining & Met. Soc. India*, **7** [3] 157–60 (1935).—P. has identified feldspars in the amygdaloids from the Lingadhalli traps by detailed optical and microchemical examination. The mineral, which often shows a radiating habit, is found to be intermediate in composition between oligoclase and andesine. P. suggests that the feldspar was derived from the alteration of previous zeolitic mineral in the vesicles. A.P.S.

Lepidolite. L. L. FERMOR. *Records Geol. Survey India*, **69** [1] 38–39 (1935).—F. records the discovery of the mineral *in situ* in Bastar State, Central Provinces, occurring as rather large fine-grained masses which, except for a little quartz, are free from impurities, the LiO_2 content being 3.34% and fluorine 4.88%. The principal use of lepidolite as such is in the glass industry, the lithia content being too low for it to serve as the raw material for the manufacture of lithium salts by ordinary chemical methods. A.P.S.

Mineral resources of Rajputana. A. M. HERON. *Trans. Mining & Geol. Inst. India*, **29** [4] 289–391 (1935).—The list comprises over forty minerals, building stones, clays, sands, and coal. Deposits of coal, building stones, gypsum, fuller's earth, and steatite are worked continuously. Of these, the sandstone and marble quarries have been in operation for centuries, while the organized salt and coal industries are of recent growth. Beryl has been mined in recent years from some of the mica pegmatites. A.P.S.

Obtaining artificial petroleums and ceramic raw materials. V. CHARRIN. *Argile*, No. 167, pp. 1–3 (1937).—After the distillation of petroleum from bituminous schists, especially pyroschists, the residual calcareous clay can be utilized in the manufacture of cement and agglomerates, brick, and tile. M.V.C.

Potash from polyhalite. Relation between calcination conditions and extraction behavior. J. M. DAVIDSON, A. A. BERK, J. E. CONLEY, AND EVERETT P. PARTRIDGE. *Ind. Eng. Chem.*, **29** [4] 475–82 (1937).—A laboratory study of the effects of calcination conditions, particle size, and sodium chloride on the extraction of potassium and magnesium sulfates by hot water from polyhalite showed that optimum conditions for calcination and extraction are those which yield the highest concentrations of potassium and magnesium sulfate in the hot extract solution. The highest feasible concentrations are 10.5 g. potassium sulfate and 7.5 g. magnesium sulfate per 100 g. water with a 96% extraction. The practical temperature range for calcination lies between 450° and 500°C; a short time at 500°C produces essentially the same effects as a longer time at the lower temperature. Two minutes' heating at 500°C is satisfactory, and 8 min. are required at 475°C. Temperatures higher than 500° or lower than 450°C are undesirable because over- or under-calcination results. Grinding to a particle size of −10-mesh is sufficient but slightly inferior to treatment of − 20-mesh material. The larger size extracts slightly more slowly but also favors a flatter time-concentration curve owing to a lesser tendency toward formation of secondary solid phases. The mechanism of calcination is the dehydration of the complex molecule with liberation of the individual compounds, followed by the gradual formation of a series of solid solutions involving dicalcium sulfate ($K_2SO_4 \cdot 2CaSO_4$) and langbeinite ($K_2SO_4 \cdot 2MgSO_4$). On extraction by hot water, dissolution occurs, with potassium, magnesium, and calcium sulfates going into solution with the simultaneous precipitation of syngenite ($K_2SO_4 \cdot CaSO_4 \cdot H_2O$) and polyhalite ($K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot 2H_2O$). The latter compound forms concurrently with and later at the expense of the syngenite. Sodium chloride tends to decrease the rate and amount of syngenite and polyhalite appearing as secondary phases. Illustrated. See "Study—," *Ceram. Abs.*, **13** [9] 224 (1934); "Potash—," *ibid.*, **15** [7] 218 (1936). F.G.H.

Quartzite of Barge. FERRUCCIO PALAZZI. *Centro Studi Ceram.*, **3** [2–6] 39 (1936).—The samples examined contained 97.5% silica and 0.085% ferric oxide. They were transparent, mostly colorless crystals of microcrystalline structure. This quartz can be used in glassmaking and ceramics. M.V.C.

Study of accessory minerals in igneous and metamorphic rocks. JOHN C. REED. *Amer. Mineralogist*, **22** [2] 73–84 (1937).—R. traces the development of the study of accessory minerals in igneous and metamorphic rocks and of the application of such study to broader problems of igneous geology, such as correlation of (or differential between) igneous masses. The paper is based largely on abstracts of the literature that have been prepared by members of a committee on accessory minerals of crystalline rocks in the Division of Geology and Geography, National Research Council, and represents a first stage in the work. The distribution of the accessory minerals in sediments will be considered in a later paper. F.J.Z.

Zeolites. A. N. WINCHELL. *Amer. Mineralogist*, **22** [2] 85–96 (1937).—The square diagrams previously used to represent the variations in composition in zeolites have been corrected and modified to include new data. As before, they show that zeolites vary in composition chiefly in the same way as feldspars and that the variation consists essentially in the addition of silica. Accordingly it is possible to consider these variations in terms of three molecules: $CaAl_2O_4$, $Na_2Al_2O_4$, and Si_2O_4. This makes it possible to represent the composition of all zeolites on ternary diagrams which are more satisfactory than the square ones previously used. Variations in optical properties, corresponding with the variations in composition, are not easily defined because variations due to other causes are commonly present; however, a diagram for them has been prepared. F.J.Z.

Zircon, its applications and its occurrence in France. V. C. *Rev. Matériaux Construction Trav. Publics*, No. 328, pp. 14–15B (1937).—Zircon and zirkite are the two principal forms of zirconium found in nature, usually in small and widely scattered quantities. Physical properties, uses, and occurrence of zirconium are reviewed. M.V.C.

BOOKS AND BULLETIN

Geology of Texas: Vol. II, Structural and Economic Geology. E. H. SELLARDS AND C. L. BAKER. *Univ. Texas Bull.*, No. 3401 (1934, distributed in 1936). 884 pp., 40 figs., 8 plates. Price $3.00. Reviewed in *Econ. Geol.*, **32** [1] 113–14 (1937).—This volume is devoted to the State's major structural features and economic mineral resources other than petroleum. For Vol. I see *Ceram. Abs.*, **13** [4] 100 (1934). J.L.G.

Kyanite industry of Georgia. RICHARD W. SMITH. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 742, 11 pp. (1936).—The location, origin, and mining and milling of the kyanite-mica schist belt in Habersham and Rabun counties of Georgia are described. The principal market for Georgia kyanite is for refractories used in the manufacture of glass. Research work on the use of kyanite in the production of high-alumina refractories for general use is being carried on. See *Ceram. Abs.*, **14** [2] 48 (1935).

Rutley's Elements of Mineralogy. 23d ed. Revised and enlarged by H. H. READ. Thomas Murby & Co., London, 1936. viii + 490 pp., 127 figs. Price 8s. Briefly reviewed in *Econ. Geol.*, **32** [1] 115–16 (1937).—The new edition contains 100 pages of added material on crystallography, optical properties, and descriptions of minerals. J.L.G.

Chemistry and Physics

Adsorption in theory and practice. M. B. DONALD. *Chem. Age*, **32**, 581–82 (1935).—Theoretical methods for determining the design and performance of adsorbing towers are described. The use of packing material and its characteristics are discussed. Use of moderate pressure is reported to increase the rate of adsorption. This is held to be an excellent method for increasing plant capacity as long as the pressures employed are not excessively high.

Mass transfer coefficient, with practical applications, is discussed. M.J.H.

Analytical chemistry of tantalum, niobium (columbium), and their mineral associates: General summary and results. W. R. SCHOELLER. *Analyst*, **61** [729] 806–11 (1936).—Begun in 1919, this investigation is now completed, and a monograph based on the 33 papers will be published. The success of the work is due to the discovery of the action of tannin in differentially precipitating these earths from tartaric or oxalic solution. See *Ceram. Abs.*, **16** [4] 132 (1937). H.H.S.

Coefficient of thermal expansion of magnesium oxide. MILO A. DURAND. *Physics*, **7**, 297–99 (1936); *Chem. Abs.*, **30**, 7409 (1936).—Data on single crystals were obtained from 85° to 480°K. Combined with Austin's data the temperature range extends to 1273°K. The observed thermal expansion agreed closely with Grüneisen's relation.

Colorimetric microdetermination of cobalt and potassium. C. P. SIDERIS. *Ind. Eng. Chem., Anal. Ed.*, **9** [3] 145–47 (1937).—The amount of potassium in the potassium-sodium cobaltinitrite precipitate is obtained indirectly by determining colorimetrically the cobalt in the acid solution of the precipitate with the use of nitroso R-salt (disodium salt of 1-nitroso-2-hydroxy-3, 6-naphthalenedisulfonic acid). It is shown that the cobaltinitrite precipitate contains potassium and cobalt in the atomic ratio 1 to 2. The nitroso R-salt gives, with cobalt solutions, an intensely colored solution of a red dye which is extremely stable. F.G.H.

Complete analysis of apatite (phosphate and fluorine-bearing) rock. C. O. HARVEY. *Analyst*, **61** [729] 817–24 (1936).—The disorganization of the ordinary group separation of metals by phosphate is overcome first by removing Ca as $CaSO_4$ in alcoholic solution. The analysis is then detailed. H.H.S.

Determination of chromium and chromite. G. TOMARCHIO. *Metallurgia Ital.*, **27**, 21–23 (1935); abstracted in *Chem. Zentr.*, **1935, i,** 3451.—The sample, dried at 105°, is treated, in a nickel crucible, with 3 g. sodium peroxide until the appearance of red color and cooled; some peroxide is added and again the melt is heated. It is dissolved with cold and boiling water and boiled for 10 minutes; some sulfuric acid (50%) is added, the solution is stored, and 200 cc. are then filtered off. The filtrate is treated with Mohr's salt and the surplus is titrated back with permanganate. M.V.C.

Determination of potassium by means of an aqueous solution of trisodium cobaltinitrite in the presence of nitric acid. L. V. WILCOX. *Ind. Eng. Chem., Anal. Ed.*, **9** [3] 136–38 (1937).—An aqueous solution of trisodium cobaltinitrite replaces the familiar two-solution reagent. Nitric acid, rather than acetic acid, is used as the acidifying agent to maintain the nitrate-nitrite equilibrium and thereby prevent nitrite decomposition. The resulting precipitate is granular, heavy, and easily filtered and washed. The gravimetric and volumetric procedures for the determination of potassium by this new method are described. The normality of the oxidizing solution bears a stoichiometric relation to the potassium of the precipitate, and the equation for the reaction is shown. The absolute accuracy as well as the reproducibility appears to be within ±0.05 mg. expressed as potassium. F.G.H.

Elementary cell of quartz and chalcedony. MARJA KOLACZKOWSKA. *Arch. Minéral. Soc. Sci. Varsovie*, **12**, 82–89 (1936); abstracted in *Chem. Zentr.*, **1937, i,** 1399.—K. discusses comparative X-ray pictures of quartz and chalcedony. M.V.C.

Fusion diagram of ternary system Na_2SiO_3–$PbSiO_3$–PbO. K. A. KRAKAU. *Izvest. Sektor. Fis.-Khim. Anal., Inst. Obshchel & Neorg. Khim.*, **8**, 331–50 (1936); *Chem. Abs.*, **30** [17] 6147–49 (1936).—Study of the composition and properties of optical glasses began with the fusion diagram of the ternary system Na_2SiO_3–$PbSiO_3$–PbO. It was prepared by melting a mixture of powdered pure quartz with Kahlbaum Na_2CO_3 and PbO in a Pt crucible. The thermal study of the fusion diagram comprised the curves of heating, cooling, and liquidus, obtained by the static method of determining equilibria. The melts were crystallized, and their optical and crystallographic properties were microscopically examined. From the temperatures of crystallization of all the melts, it was possible to construct the fusion isotherms, taken mostly at intervals of 50°. On the basis of the microscopic examination of the separated crystals, the entire system can be divided into 5 crystallization fields, corresponding to the compounds $Na_2O{\cdot}SiO_2$, PbO, $3PbO{\cdot}SiO_2$, $2PbO{\cdot}SiO_2$, and $PbO{\cdot}SiO_2$. The borders of these fields are divided by lines descending to the lowest point of the composition in molecular percentage of SiO_2 50, PbO 32.5, and Na_2O 17.5, and the melting point 570°. The crystallization field of $Na_2O{\cdot}SiO_2$ is greater than the other fields and is shaped like a conical surface with the summit in the point of the metasilicate (melting point 1088°). From the summit, the surface descends in the direction of increased PbO content, at first somewhat slowly and then, nearer to the eutectic line, very abruptly. At the borders of the system (lines PbO–$Na_2O{\cdot}SiO_2$ and $PbO{\cdot}SiO_2$–$Na_2O{\cdot}SiO_2$) the descent is not so sharp, but, because of this descent in the direction of the center line, a more elevated part of the surface (a hump) is obtained. Next in magnitude is the crystallization field of PbO, including a sector whose character of fusion equilibria is not fully clarified. On the line PbO–$Na_2O{\cdot}SiO_2$ and the nearest one for a considerable length, the crystallization temperatures differ little from each other. The remaining sector of this field represents a surface descending to a line of division from the highest point PbO (melting at 886°). The crystallization field of $3PbO{\cdot}SiO_2$ is indicated only approximately. Doubtless it is not very large and corresponds to this compound. The crystallization fields of $2PbO{\cdot}SiO_2$ and $PbO{\cdot}SiO_2$ are approximately equal and do not reach to the center of the diagram (in the direction of decreasing PbO contents). The highest points in these fields are formed by the definite compounds of $2PbO{\cdot}SiO_2$ (melting at 746°) and $PbO{\cdot}SiO_2$ (melting at 765°).

Hardness and hardness measurements: III, Atomic structure in relation to hardness. S. R. WILLIAMS. *Instruments*, **10** [3] 68–71, 82 (1937).—Modern views relative to atomic structure are discussed and are illustrated by models. For Part II see *Ceram. Abs.*, **16** [5] 156 (1937). R.W.R.

High-temperature inorganic reactions in the absence of a liquid phase. F. J. WILLIAMS. *Crucible*, **21**, 50–52 (1937).—Diffusion of one solid into another is necessary

for reaction. The products may influence the rate of the reaction by acting as a barrier or a catalyst or they may have no apparent effect. The system CaO–MgO–SiO_2 is described in detail. See "Reactions—," *Ceram. Abs.*, **15** [5] 169 (1936). W.D.F.

Investigations on the oxides of lead. EDOUARD RENCKER. *Bull. Soc. Chim.*, [5] **3**, 981–88 (1936); *Chem. Abs.*, **30**, 7056 (1936).—PbO_2 decomposes on heating in air into the intermediate products Pb_2O_3 and minium. Heated *in vacuo*, a brown oxide other than minium, but of the same composition, is obtained; it is changed to minium at 420°. The α-protoxide varies from red to yellow, while the β-form is darker yellow; α transforms into β at 530°, but the opposite change is not observed directly. β, in contact with S, changes into α.

Reactions of kaolin and halloysite. STANISLAW J. THUGUTT. *Arch. Minéral. Soc. Sci. Varsovie*, **11**, 122–33 (1935); *Chem. Abs.*, **30**, 7502 (1936).—H. Stremme states, on the basis of thermal analyses, that the constitutions of kaolin (I) and halloysite (II) are identical. X-ray diagrams of both minerals prepared by M. Kolaczkowska are alike, except that the rings next to the primary ray are less distinct in the case of II, a fact which is explained by smaller dimensions of the crystallites. T. heated I from Karlsbad and II from Lubien in a 2% and a 0.12% solution of NaOH during 100 hr. at 220°, and the solid crystalline residues after the reaction were different. Prolongation of the time of action of 0.12% NaOH upon II proved that the differences did not depend on the rate of corrosion caused by a different size of the grain. More Al_2O_3 was dissolved from I than from II. Action of a 0.16% KOH solution upon II during 100 hr. at 215° to 219° gave a noncrystalline product, as evident from X-ray analysis, different from that in the case of I.

Manganese problem in silicate analysis and its solution. O. HACKL. *Jahrb. Geol. Bundesanstalt.*, pp. 65–68 (1936); abstracted in *Sprechsaal*, **69** [44] 644 (1936).—H. deals with a critical analysis of methods used for determining manganese in silicate analysis which are unsatisfactory and difficult. The main disadvantages of present methods are listed. Even with repeated precipitation of aluminum, iron, etc., with an ammonium hydroxide solution, part of the manganese is carried down with the sesquioxides so that the filtrate does not contain the total manganese. The precipitation of manganese with ammonium sulfide is incomplete; too high values are obtained, however, when the remaining amounts of alumina and iron dissolved in the filtrate are not precipitated before. This precipitation is therefore omitted and the manganese is divided in the calcium and magnesium sediments. The subsequent determination of manganese in the magnesium sediment yields only a part of the Mn, while its determination in the calcium sediment affects the subsequent determination of strontium. When determining the total Mn in a separate precipitate to determine the quantity of Mn remaining in the sesquioxides from the difference of the sum of Mn present in the Ca and Mg deposits, a part of the manganese remains in solution even after the Mg precipitation. A direct determination of Mn in the sesquioxides precipitate is very difficult. The acetate method often produces, in the filtrate, turbid wash water and large amounts of aluminum and iron which must be precipitated from the filtrate with special care. Otherwise, the same errors will occur as in the treatment with ammonium hydroxide. Manganese may be completely dissolved by hydroxylamine with ammonium hydroxide precipitation; the effect of hydroxylamine on the subsequent silicate analysis is known. With the further treatment of the filtrate, the same difficulties appear as with the ammonia and acetate methods. The total Mn can be precipitated with the sesquioxides by oxidation and determined in a sample separate from the sesquioxides. Good results can be obtained in this way; it is an expedient, however, and not a solution. The various other methods developed and suggested show more or less the same difficulties and disadvantages. M.V.C.

Mechanics of solid bodies. THEODOR PÖSCHL. *Physik*, **4** [4] 131–44 (1936).—P. reviews the entire literature dealing with the physical and technical properties of solid bodies and their various testing methods. Such properties as elasticity, tension and compression, torsion and bending, elongation, plasticity, fatigue, and corrosion are mentioned. L.E.T.

Microchemical analysis of pigments. A. A. BENEDETTI-PICHLER. *Ind. Eng. Chem., Anal. Ed.*, **9** [3] 149–52 (1937).—Methods used in the analysis of pigments found in incisions of archeological specimens are described and illustrated. F.G.H.

Portion of the system CaO–Al_2O_3–Fe_2O_3. HOWARD F. MCMURDIE. *Jour. Research Nat. Bur. Standards*, **18** [4] 475–84 (1937).—A study has been made of the solidus and liquidus relations in the area CaO–4CaO·Al_2O_3–CaO·Al_2O_3. Special attention has been given to the study of solid solutions. It was found that 3CaO·Al_2O_3, 5CaO·Al_2O_3, and CaO·Al_2O_3 all take Fe_2O_3 up to 2.5% into solid solution. 4CaO·Al_2O_3·Fe_2O_3 also takes between 3 and 5% of the calcium aluminates into solution. In some cases, the solid solution relations are such as to shift the conjugation lines away from the joins. R.A.H.

Pyrosols: Solutions of metals in molten salts. ERICH HEYMANN. *Jour. Australian Chem. Inst.*, **4** [2] 38–51 (1937).—Formerly thought to be colloidal, these solutions are now regarded as true atomic solutions. The behavior of the metal in the molten salt is discussed. The practical significance of the subject is exemplified by metals in slags and by the geological distribution of gold and other metals between the silicate shell and the interior of the earth. H.H.S.

Rapid method of determining the quality of water-glass. V. A. ZALESSKIĬ. *Zhur. Priklad. Khim.*, **9** [6] 1136–40 (1936).—The Winkelmann-Schott formula for calculating the specific weight of solid glass has been modified and applied to soluble glass as follows:

$$M = A\,\frac{d-1}{dn} + B$$

where M = modulus of soluble glass, d = specific weight of solution, n = percentage of alkalis, Mn = percentage of silica, and A and B = constant values. The formula permits determination of the quality of commercial varieties of soda water-glass. The method is to be tested to make the formula more accurate; in particular, corrections must be applied to samples containing over 45% of solid matter and possessing a specific gravity over 1.5. P.B. & E.S.

Rational analysis of refractory clays. V. B. KRAFT AND T. A. GURVICH. *Zavodskaya Lab.*, **5** [8] 954–62 (1936).—Check tests of different methods demonstrated that the Bollenbach and Harkort are the best of the existing methods, separately or combined. The combined method makes it possible to determine peculiarities in the properties of clays that are connected with the size of the kaolinite grains. The Harkort method permits checking the results obtained with the aid of simple formulas. See "Determining iron oxide—," *Ceram. Abs.*, **16** [2] 74 (1937). P.B. & E.S.

Recent high-temperature research on silicates and its significance in igneous geology. NORMAN L. BOWEN. *Amer. Jour. Sci.*, [5] **33** [193] 1 (1937).—B. briefly summarizes some of the silicate equilibrium diagrams determined at the Geophysical Laboratory, with applications to the crystallization of igneous rocks. Hitherto unpublished diagrams are given for the following systems: anorthite ($CaAl_2Si_2O_8$)–leucite ($KAlSi_2O_6$)–silica, diopside ($CaMgSi_2O_6$)–leucite–silica, and carnegieite ($NaAlSiO_4$)–FeO–silica. In the first two systems, the low-melting liquids lie close to the potash-alumina side, and fractional crystallization of the liquid results in impoverishment in anorthite and diopside, respectively. J.B.A.

Röntgenographic research on ceramic masses in Japan. FUJII KANEKOTO. *Repts. Imp. Ceram. Expt. Inst.* (Tōjikishikensho), No. 16, pp. 71–80 (1936); abstracted in *R ferat. Silikatliteratur*, **4** [1] 3654 (1937).—Röntgenographic studies of ceramic bodies made it possible to distinguish different glazes and coloring substances as well as tensions and flaws in the ware. M.V.C.

Temperature dependence of "place exchange" in alumina. H. VON WARTENBERG AND G. WEHNER. *Nachr. Ges. Wiss. Göttingen, Math.-Physik. Klasse, Fachgr. 3*, **1** [15] 157 (1936); abstracted in *Sprechsaal*, **69** [44] 643 (1936).—The exchange of places of components of combinations rapidly increases with rising temperature in reactions in the solid state. This exchange of place can be detected from the solidification of powders and changes in electric resistivity. The exchange of places between cations of adjacent crystals can be directly seen in alumina; therefore, the coefficient of temperature of the velocity of this exchange can be determined. When 2 or 3% chromic oxide is added to alumina, Cr''' is formed instead of Al''' at a sufficiently high temperature, and this formation occurs with an exchange of color from green to red (formation of ruby). This sudden change is influenced by changed electric fields to which Cr''' is exposed in the Al_2O_3 lattice and is an unmistakable proof of place exchange. When alumina-chromic oxide mixtures are calcined, the color gradually turns from green to gray-white and from red-gray to red; the change of light gray to red-gray is the most visible. Pieces of 1 mm. thickness made from this mixture were gradually heated to the point where they had the same color as the samples calcined at 1600°C for ½ hr. Several hours are required to produce exchange of place at lower temperatures; minutes are sufficient to produce change of color at higher temperatures. Experiments show that the coefficient of temperature of the speed of reaction is large because only 30° are required to double the speed of reaction even between 1500° and 1800°C. Coarser grains lower the speed of reaction threefold; the temperature coefficient remains unchanged. The "heat of loosening" is about four times as large as that of the diffusion of mixed crystals in alloys and of reactions in the solid state. Because the reactions in the solid state were studied with bivalent metallic oxides which possess a "heat of loosening" of about 20 to 40 cal., the four times-greater "heat of loosening" of Al_2O_3 corresponds to the four times-greater lattice energy of Al_2O_3 with which the very high resistivity of sintered corundum is connected; the lattice of sintered corundum is strong and goes into exchange with the other materials difficultly. M.V.C.

Volatile transport of silica. RUTH D. TERZAGHI. *Amer. Jour. Sci.*, [5] **28**, 391 (1934).—In connection with the work of Greig, Merwin, and Shepherd (*Ceram. Abs.*, **13** [7] 191 (1934)), it is pointed out that Willstätter, Kraut, and Lobinger (*Ber. Deut. Chem. Ges.*, **58**, 2462 (1925); **61**, 2280 (1928); **62**, 2029 (1929); *Ceram. Abs.*, **8** [5] 372 (1929)) also observed the volatilization of SiO_2 at temperatures under 100°C. They suggest that to have such transport the silica must be present not as monosilicic acid but in a less hydrated form. J.B.A.

BOOK AND BULLETINS

Reports on Progress in Physics: Vol. III. ALLAN FERGUSON, General Editor. Published by the Physical Society, London, 1937. 394 pp. Price 20s. This volume contains sixteen chapters each devoted to a review of recent advances in a particular branch of physics. Detailed discussion is given in only a few cases, most of the summaries being limited to a brief abstract of the more important papers. These abstracts differ from the usual condensations found in abstract journals in that they frequently contain critical comments by the chapter editor and are also more closely correlated and compared. The literature has been carefully covered and the work should prove useful as a source book. The chapter headings are General physics, Fluid motion, Upper atmosphere, Atomic physics, Conservation of energy and momentum in elementary processes, Sound, Measurement of noise, Heat, Magnetism, Experimental electricity and magnetism, Electrical methods of counting (atomic or molecular particles), Superconductivity and the theory of metals, Photoelectricity, Optics, X-rays, and Spectroscopy. The only chapter likely to be of interest to ceramists is the one on heat, written by R. W. Powell of the National Physical Laboratory, which contains the following sections: Production and measurement of various temperatures (from 0.02° to 2000° abs.), Calorimetry and allied thermodynamics, Conduction, Radiation, Convection and evaporation, Hygrometry, and Dilatation. There are 177 references in this chapter. J.B.AUSTIN

Theoretical Metallurgy: III, Free Energies of Vaporization and Vapor Pressures of Inorganic Substances. K. K. KELLEY. *U. S. Bur. Mines Bull.*, No. 383, 132 pp. Price 10¢. K. discusses methods used in heat and free energy of vaporization calculations, gives heat and free energy of vaporization equations for all the elements and inorganic compounds for which the necessary data are available, and summarizes vapor-pressure results for the substances discussed. A bibliography of vapor-pressure data, complete as far as possible up to April, 1934, is included. **IV, Metal Carbonates—Correlations and Ap-**

plications of Thermodynamic Properties. K. K. KELLEY AND C. T. ANDERSON. *Ibid.*, No. 384, 73 pp. Price 10¢. The authors assemble existing thermodynamic data for carbonates and correlate the results of decomposition-pressure determinations with the calorimetrically determined heats of formation and entropy values on one hand and with solubility and standard electrode-potential data on the other. **VI, Revision of the Entropies of Inorganic Substances—1935.** ANON. *Ibid.*, No. 394. 55 pp. Price 10¢. This bulletin supplements *ibid.*, Nos. 350 and 383. New values are given, and revisions are made in the older values as the data warrant. For Part V see *Ceram. Abs.*, **16** [5] 162 (1937). R.A.HEINDL

PATENTS

Manufacture and production of cryolite. G. W. JOHNSON (I. G. Farbenindustrie A.-G.). Brit. 463,092, April 1, 1937 (Jan. 6, 1936).

Process for recovering zirconium oxide. HENRI GEORGE AND ROGER LAMBERT (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey). U. S. 2,076,080, April 6, 1937 (Nov. 27, 1934).

Production of sodium aluminium fluoride. WALTER STRATHMEYER (I. G. Farbenindustrie A.-G.). U. S. 2,075,370, March 30, 1937 (June 30, 1936). A process for the production of sodium aluminium fluoride consists in dissolving 78 parts of aluminium hydroxide having a content corresponding to 64% of Al_2O_3 in 415 parts of 29% caustic soda solution and introducing this solution into a solution of 222 parts of ammonium fluoride in 300 parts of water while stirring, removing the ammonia formed by heating to about 80° to 90°C, filtering off the precipitate, washing, and drying it.

General

Avoidable accidents and injuries to health in the glass industry. GUTMAN. *Glashütte*, **67** [6] 91–94; [7] 106–108 (1937).—Methods used for the protection of workmen's health in the German glass industry are briefly described. See "Workers'—," *Ceram. Abs.*, **16** [3] 88 (1937). M.V.C.

Chinese standard metric weights and measures. H. G. W. WOODHEAD. *China Yearbook*, **18**, 483 (1936).—China has adopted the metric system, but has given its own names to the units. H.H.S.

Clay through the ages. J. A. VERMESS. *Clay Prod. Jour. Australia*, **4** [4] 17–18 (1937).—The varieties of clay and the uses to which they have been put since the earliest times are described. H.H.S.

Coal-handling improvements at Miller's Ford station, Dayton, Ohio. R. D. GILLESPIE. *Combustion*, **8** [5] 41–43 (1936).—The new high-pressure extension being made to this station necessitates considerable rearrangement of the plant layout, involving the replacement of one of the existing coal towers with a modern, fully automatic skip hoist system of increased capacity. The new system eliminates the dust nuisance which prevailed with the old system of hoisting coal with grab buckets. H.E.S.

Combating dust in the refractory industry. WERNER FAUST. *Tonind.-Ztg.*, **61** [6] 59–61; [7] 74–76 (1937).—Suction apparatus and other devices for eliminating dust and safeguarding the health of workers at the Didier-Werke A.-G. are described. Masks worn by the workers are illustrated. M.V.C.

Dust research: microscopic study of typical Italian dusts. L. SANTARELLI. *Ann. Chim. Applicata*, **27** [1] 3–14 (1937).—Italian dusts have received little microscopic study; Gallo (1908) began it. S. comments on the few intervening works before the series he has been carrying on. The present study concerns dusts in localities near Rome, Naples, Thessaly, *i.e.*, in the zones Laziale, Flegrea, and Vulture. Their crystalline structure enabled identification with rocks of their origin, as they have been subjected to slow amorphous changes. Twenty-four photomicrographs are given with comments and a table of analytical results. The data are to be evaluated for possible technical use. K.R.

Enlargement and reduction. ERNST BEHR-AUE. *Sprechsaal*, **69** [45] 655–57 (1936).—Methods used in enlarging or reducing the dimensions of ware are described. Illustrated. M.V.C.

Good light, sound eyes, and successful work. W. HAHN. *Sprechsaal*, **69** [49] 723–24; [50] 737–38 (1936).—Suggestions are given for adequate illumination of brickworks and related plants. Illustrated. M.V.C.

Law as applied to trade-marks and trade names. L. T. PARKER. *Combustion*, **8** [4] 41–42 (1936).—What constitutes a trade-mark, what trade-marks may be registered and how, comparison of infringing marks, the difference between trade-marks and trade names, and the right to use one's name are discussed in the light of numerous court decisions for the purpose of enabling manufacturers and engineers to avoid costly litigation through thoughtless infringement. H.E.S.

Law of tools and equipment. L. T. PARKER. *Combustion*, **8** [6] 33–34 (1936).—P. reviews the law, as interpreted by recent court decisions, applying to employer liability in cases of injury sustained by employees through the operation or handling of equipment. Liability under the common law is distinguished from coverage by workman's compensation laws. H.E.S.

Henry LeChatelier: I, His life and work. ALEXANDER SILVERMAN. *Bull. Amer. Ceram. Soc.*, **16** [4] 155–63 (1937).

Walter Scott Lenox. GEORGE SANFORD HOLMES. *Bull. Amer. Ceram. Soc.*, **16** [4] 177–80 (1937).

Load distribution for best over-all economy. E. D. ST. JOHN. *Combustion*, **8** [3] 30–35 (1936).—S. describes a system for determining mathematically the most efficient loading of turbines, boilers, and generating stations, based on the theory that the most economical distribution of load occurs where the rate of change in total input to the units is the same. H.E.S.

Microscopic investigation of polished surfaces of some ceramic masses (roofing tile). MARTHA ANDRÄ. *Keram. Rundschau*, **43** [25] 289–90 (1935).—The samples taking a

good polish show a bright network under vertical illumination (60 magnification). This network is the result of the sintering obtained after sufficient firing. Before contraction, there is a transient increase of the volume of the pores and also of water permeability. Half-sintered tile is a nuisance. Overfired material has large pores above capillary magnitude; they have practically no power of water absorption. The development of the network for clay and kaolin heated at progressive temperatures is illustrated. F.E.V.

Organic and inorganic glass. W. O. *Diamant*, **59** [4] 38 (1937).—The trade names of glasses and glasslike products should indicate their physical nature, whether organic or inorganic. The difference between enamels and enamel lacquers should also be indicated by the trade name. M.V.C.

Particle packing and particle shape. H. E. WHITE AND S. F. WALTON. *Jour. Amer. Ceram. Soc.*, **20** [5] 155–66 (1937).

Presidential address. FRANCIS C. FLINT. *Bull. Amer. Ceram. Soc.*, **16** [4] 164–66 (1937).

Recent progress in dielectric research. JOHN B. WHITEHEAD. *Elec. Eng.*, **55** [11] 1180–85 (1936).—W. reviews the salient points reported in technical literature during the past year covering (*a*) dielectric strength and breakdown, (*b*) stability, (*c*) dielectric loss and phase difference, (*d*) dielectric constant and capacitance, and (*e*) new applications and materials. In solids, breakdown may be either thermal or nonthermal. The former is less frequent than commonly supposed. New insulating materials are being developed which vary from the rigid ceramic type to liquids. Materials of high dielectric constant are tin oxide, rutile, Seignette salt, and Styroflex, a material like flexible glass and used as cable insulation. 52 references. G.M.P.

Respiratory protection. ED. SMOLCZYK. *Gasmaske*, **8**, 109–17 (1936); *Chem. Abs.*, **30**, 8426 (1936).—A moving-picture film illustrates filter-type gas masks, O-breathing apparatus, fresh air or hose masks, and military equipment for protection against air raids. These various types of apparatus are described and their use is illustrated by enlarged sections from the film.

Sulfate determinations and their application to plant control. L. D. BETZ. *Combustion*, **8** [3] 43–45 (1936).—Certain well-known methods of analyzing feed and boiler waters are not well-suited to plant control unless the plant has laboratory facilities with personnel trained in making chemical analyses. Two comparatively recent methods, the turbidimetric and the "THQ" methods, are of considerable promise because of their simplicity and applicability without requiring laboratory facilities. The methods are described. H.E.S.

Why clay rules in the construction field. EDITORIAL. *Clay Prod. Jour. Australia*, **4** [4] 1–2 (1937).—Clay, whether as brick or as pipe, stands by itself as a durable material impervious to liquids, acids, and gases. When clay apparently fails, it is found that the mortar between the brick or the cement joining the pipes has failed and not the clayware. Concrete houses built since the War by the British Government are already being pulled down. H.H.S.

BOOKS

New Zealand Official Yearbook, 1937. J. W. BUTCHER. G. H. Loney, Govt. Printer, Wellington, New Zealand. 45th year, 894 pp., map. Price 7s 6d. The book contains industrial statistics and abstracts on lime, cement, brick, and pottery. H. H. STEPHENSON

Symposium on Utilization of Blast-Furnace Slags in the Building Industry. Edited by P. P. BUDNIKOV, M. YA. LATASH, M. M. BOROK, AND S. B. BUTOM. State Sci. Tech. Press Ukraine, Kharkov, 1936. 276 pp. The symposium contains a series of papers read at the first conference on the use of blast-furnace slags in the building industry held at Dnepropetrovsk, March, 1935. The conference summarized recent experience in the building, cement, and metallurgical industries and scientific institutions of the U.S.S.R. and put forward new problems in the field of utilization of blast-furnace slags. P.B. & E.S.

PATENTS

Ceramic compositions. J. B. STALHANE. Brit. 462,781, April 1, 1937 (July 19, 1935).

Heat-resisting spools and rollers. I. G. FARBENIND. A.-G. (Carl Schörg, Karl Frank, and Karl Dietz, inventors). Ger. 625,931, Feb. 18, 1936; Cl. 21*h*. 1; *Chem. Abs.*, **30**, 5746 (1936).—The spools and rollers consist of wire embedded in a mass of fluosilicate and quartz-glass meal. Thus, the embedding mass consists of 41% fine quartz meal, 41% coarse quartz-glass meal, 10% fine quartz-glass meal, 5% fine siliceous sinter, 3% Na_2SiF_6 and K water-glass solution. The product can be heated to 1000°.

Method of forming ceramic bodies. H. M. KRANER (Feldspathic Research Corp.). U. S. 2,075,445, March 30, 1937 (Aug. 27, 1932). The method of forming ceramic bodies consists in mixing a batch of material having substantially the soft nonabrasive and long firing-range character of pyrophyllite which will form the bodies to have in the dry-press form an average hardness less than the hardness of like bodies made from an ordinary dry-press batch, in providing a die harder than any constituent of substantial proportion in the batch, in successively pressing portions of the batch in the die to form the bodies, and in firing the bodies at a given temperature for a given length of time to render them at least partially vitrified.

Process of coloring granular slate, etc. H. C. FISHER (Minnesota Mining & Mfg. Co.). U. S. 20,295, March 16, 1937 (Nov. 6, 1933); reissue of original U. S. 1,742,440, Jan. 7, 1930. The process of producing glazed granular material consists in depositing, on granular mineral matter which will withstand a roasting treatment, a metal salt and a soluble silicate which will react to form an insoluble metal glass and then subjecting the granules to heat and agitation to fuse the metal silicate on the granules without permanent agglomeration of the granules together.

Fortieth Annual Meeting

AMERICAN CERAMIC SOCIETY

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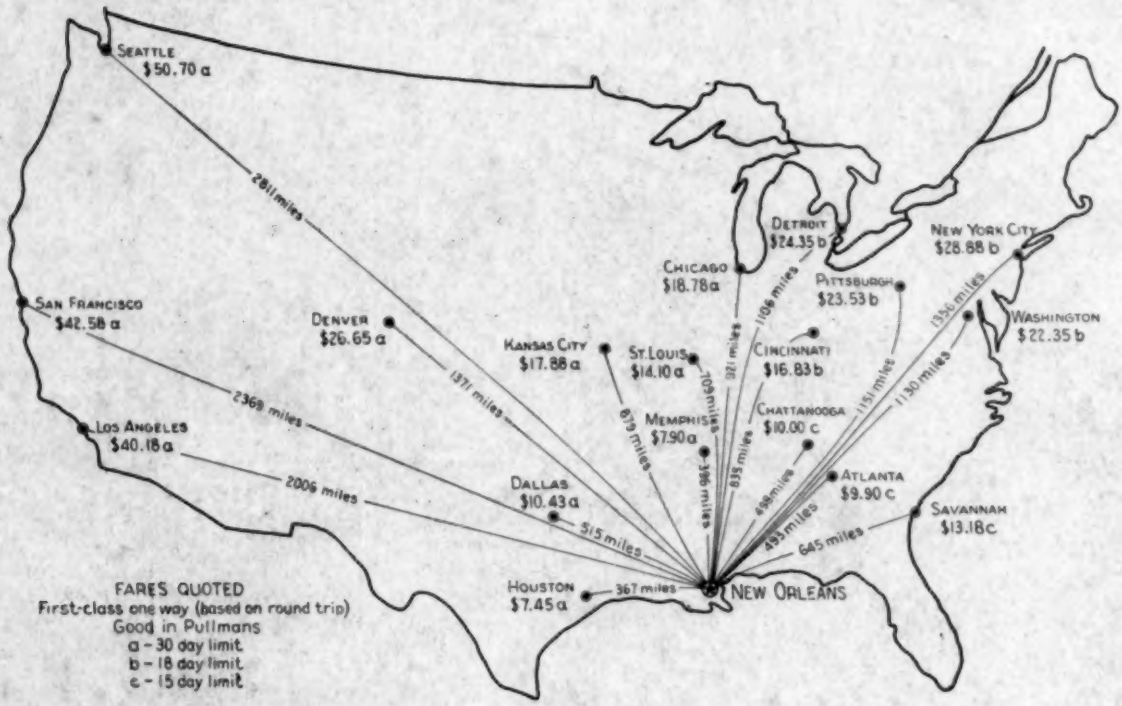

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